JULY 6, 1961

MACHINE DESIGN

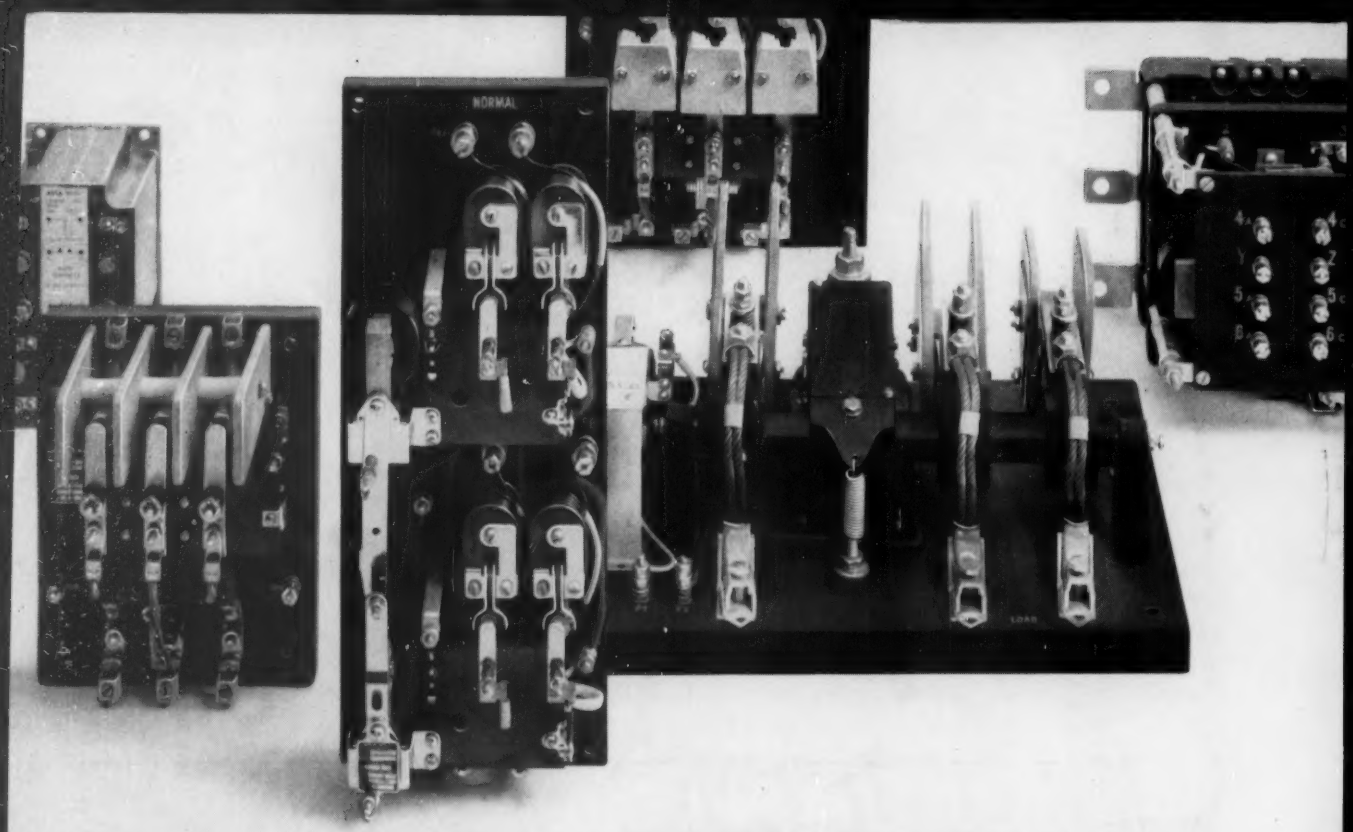
A PENTON PUBLICATION — BIWEEKLY

Roller-Chain Ratings

Contents, Page 3

MR. STEVENS RICE
UNIVERSITY MICROFILMS
313 N. FIRST ST.
ANN ARBOR, MICH.

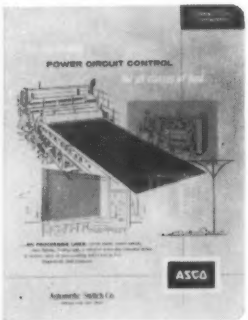
FARNSWORTH



IS THAT "SPECIAL" CONTACTOR YOU NEED A "REGULAR" AT ASCO?

The tremendous variety of "regular" contactor designs produced by ASCO is the outgrowth of unequalled experience in the engineering of "special" control mechanisms. While this know-how *can* be put to work to resolve your unusual control problem, chances are that the solution is already on an ASCO shelf.

Often a slight modification of one of the many versatile ASCO designs will perfectly adapt it for performance to your most stringent specifications. All ASCO Magnetically Held Contactors are designed for flexibility to permit unusual contact materials, uncommon multipole contact arrangements, ac and dc arrangements, and a host of other engineered-to-fit features.



Is your requirement sustained low contact resistance? High interrupting capacity? Must your contactors close against transformer inrush currents of 30 times steady state? Do you require insulation for high voltage with cold switching?

ASCO Contactors meet these problems and many others. Contactors are available to 2000 amperes, 600 volts ac or dc.

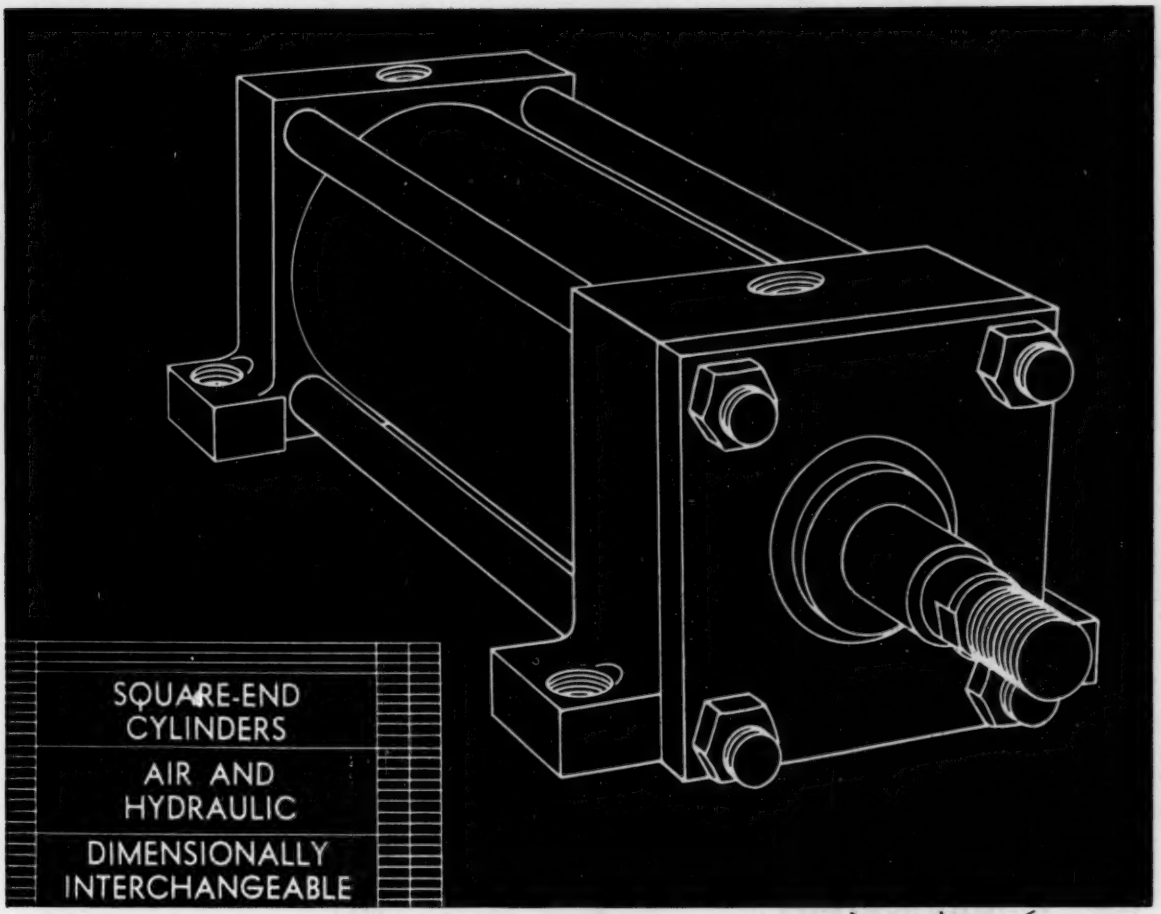
Catalog 57-S3, available on request or from your local ASCO representative, illustrates many unusual Magnetically Held Contactors. One of these "regulars" may meet your needs precisely.

ASCO Electromagnetic Control

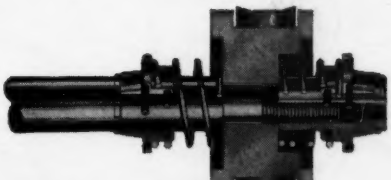
ASCO®

DEPENDABLE CONTROL BY Automatic Switch Co. 54A HANOVER RD., FLORHAM PARK, N. J. • FRONTIER 7-4600 • AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

Circle 201 on Page 19



How MEAD takes the BUMP out of high-speed pistons



FULL FLOATING CUSHIONS

Detail shows two-stage feature of full floating cushion on a piston used for hydraulic pressures over 250 psi. MEAD Square-End Cylinders also offer these other design advantages:

- Seamless, hard drawn, micro-finish brass barrel for long piston seal life
- Cold drawn steel cylinder heads with all surfaces permeated with black oxide for rust resistance
- High tensile chrome plated steel piston rods
- Accurately machined rod bearing cartridge made of solid bearing bronze

Special *full floating cushions* in new MEAD Square-End Cylinders are uniquely mounted on springs rather than on solid studs. The result is a smooth, high-speed piston advance without the use of ball checks. In hydraulic units, the two-stage design of the floating cushions completely eliminates bumping. Fully adjustable from the slightest measurable cushioning effect to complete stoppage, the full floating feature also reduces cushion wear caused by impurities in the working medium. In air models up to 250 PSI and hydraulic units up to 1000 PSI, MEAD Square-End Cylinders are available in a full range of bore, stroke and piston sizes. Complete selection of mounting styles. All units are dimensionally interchangeable and conform to JIC specifications. For consultation and information on quick delivery and competitive prices, write to MEAD *today*.

PRODUCTS FOR AUTOMATION

MEAD

FLUID DYNAMICS

A DIVISION OF MEAD SPECIALTIES CO.
4114 N. Knox Ave., DEPT. 101A, Chicago 41, Ill.

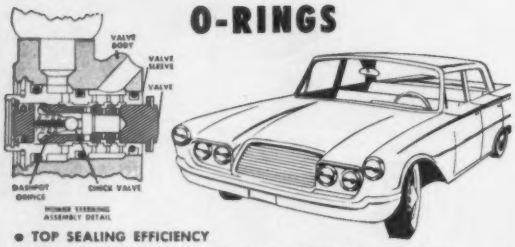
ASK YOUR MEAD MAN about 24-hour service on most MEAD products . . . 48 hours on special orders.

Circle 204 on Page 19

MINNESOTA MR RUBBER

SEALS *for Every Requirement!*

O-RINGS



- TOP SEALING EFFICIENCY
- HIGH DENSITY • WEAR RESISTANT • CUSTOM COMPOUNDS

INJECTION MOLDED O-RINGS

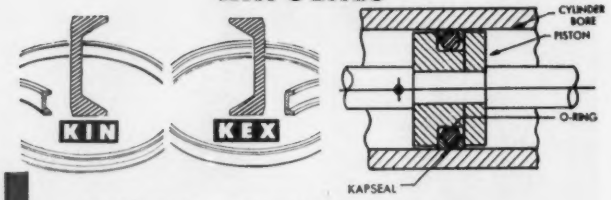
. . . give better service in any application

Minnesota Rubber injection molded O-rings always perform more efficiently and have a longer service life than ordinary O-rings because they do not have any variations in cross-sectional thickness.

In addition, the higher, more uniform density of rubber makes them highly resistant to chemicals and wear due to abrasion.

MR O-rings can be furnished out of the economical, yet durable industrial standard compound 366Y, or if your application requires it, Minnesota Rubber engineers will come up with a customized compound that exactly fits your needs.

KAPSEALS®

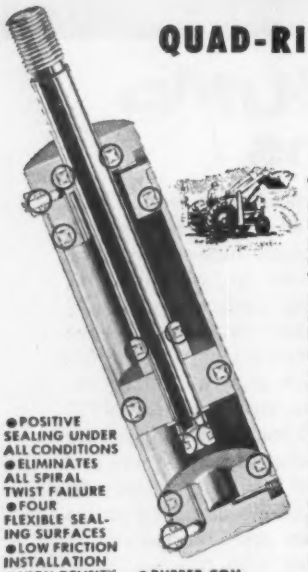


LONG LIFE LOW FRICTION SEALING

The KAPSEAL® is a Teflon® boot which is used in combination with a standard O-Ring to give superior sealing performance and eliminate breakout friction. It comes in two styles, KIN and KEX. KIN is used in applications when the ID of the seal is the sealing surface, while KEX is used when the OD is the sealing surface.

A seal of this nature was needed for applications which involved long periods of time on stand-by or in storage, as well as applications requiring continuous, non-failing operation. Tests lasting over 4 million cycles give a good indication of the KAPSEAL's potential.

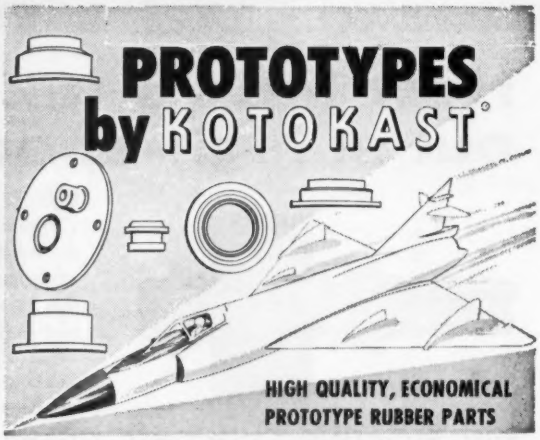
QUAD-RINGS®



- POSITIVE SEALING UNDER ALL CONDITIONS
- ELIMINATES ALL SPIRAL TWIST FAILURE
- FOUR FLEXIBLE SEALING SURFACES
- LOW FRICTION INSTALLATION
- HIGH DENSITY INJECTION MOLDED
- RUBBER COMPOUNDS TO FIT APPLICATION

The MR QUAD-RING gives superior sealing performance in hydraulic and pneumatic applications, either static or dynamic. The four lipped design prevents the rolling effect found with O-rings, thereby eliminating the common spiral twist failure. This exclusive design features four flexible sealing lips and permits installation with less squeeze, reducing friction, breakout force and wear. QUAD-RINGS can be made out of rubber compounds which exactly match the application. You can be sure of positive sealing when you use QUAD-RING SEALS in all your installations.

PROTOTYPES by KOTOKAST®



CLOSE TOLERANCES—Tolerances are identical with those that will be found on standard production parts.

FAST SERVICE—Usually it will take only hours from the time the order is received to produce twelve prototype parts using PROTOTYPES by KOTOKAST.

ECONOMY—This is the most economical method of producing prototype parts there is.

NO LIMITATION—PROTOTYPES by KOTOKAST has been successfully applied to a wide variety of designs ranging from a simple washer to intricate molded parts.

FOR MORE INFORMATION ON . . .

QUAD RINGS®. . . KAPSEALS®. . .

O-RINGS OR PROTOTYPES BY KOTOKAST

WRITE

MINNESOTA MR RUBBER

DEPARTMENT 859 • 3630 WOODDALE AVENUE

MINNEAPOLIS 16, MINNESOTA

Circle 205 on Page 19

Front Cover: Artist George Farnsworth underscores the attention recently given to roller chain standards by manufacturers. On Page 126, J. F. Pfrank and C. O. Sundberg explain the new horsepower and speed ratings, and tell how to put them to work most effectively.

July 6, 1961

Zeus: Uncertain Fate of a Missile Killer 24

News Report—Questions as to its worth, in light of the high price tag, have clouded the future of America's most successful missile-hunting missile.

Technical Specifications 112

A. J. FITZGERALD and ROWEN GLIE—A guide to the effective administration and control of the flow of technical information into and out of a company.

New Roller-Chain Horsepower Ratings 126

J. F. PFRANK and C. O. SUNDBERG—Getting the most out of the new horsepower and speed ratings proposed by chain manufacturers.

Preventing Electronic Hot Spots 130

FRANK WILLIAM WOOD Jr.—Component layout and assembly techniques.

Flexible-Beam Suspensions 134

DARRELL A. FROHRIB—*Part 1: The problem . . . design approach . . . resonant-frequency charts*—How to design a flexible-beam suspension with safe vibration characteristics.

Matching Servovalve and Load 148

R. J. PROCACCINO—Principles of single-stage servovalves; analysis of four-way servovalve controlling load cylinder; transfer functions.

Preventing Fatigue Failures 154

F. B. STULEN, H. N. CUMMINGS, and W. C. SCHULTE—*Part 6: Biaxial Fatigue Stresses*—How to relate multiaxial fatigue stresses to a single allowable fatigue stress.

Stepped Shafts and Nonuniform Beams 159

R. BRUCE HOPKINS—*Data Sheet*—A straightforward method for predicting deflections at any point in a stepped shaft or variable-section beam.

Glasses and Ceramics 166

J. R. BLIZARD—*Design Abstracts*—A design guide to the properties, applications, and advantages of various types of glasses and ceramics.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

July 6, 1961
Volume 33 — No. 14

Later Than You Think? 111
BEN HUMMEL—*Editorial*

Engineering News 6

MG Midget; New Sprite .. 6
NBS information retrieval .. 8
Topics 8
Tape-controlled gage 10
Air-regeneration system 10
Powdered insulation 12
Rust-preventive film 12
Superconducting transformer 12
Alcoa design awards 14
Atom-smasher magnet 14
Spaceship explosion hazard 15
Automatic draftsman 28
High-frequency ignition 35
Foot-soldier jet assist 35
Bearing stresses 36
Exotic bearing lubricants .. 36
Trends 22
Picture Report 30
Meetings and Shows 43
Short Courses and Symposia 44

Scanning the Field for Ideas 118

Movable pivot point provides pump adjustment—virtual hinge point allows door to operate on double-curved surface—tapered valve shroud produces gradual decrease of flow area—linkage provides equal but opposite rotation of pivot points—spring flaps open or close valve—vane-released cam triggers torque multiplier—plug valve provides increased tolerance for solids in suspension—triple-wafer deck doubles capacity of subminiature switch—load-displaced disc controls output current—twin-recording heads produce artificial music—fluid-powered poppet uses energy of fluid being controlled—flexure-mounted armature detects excess vibration—bag injects fluid into primary stream—fluid shear resistance transmits torque in hydraulic coupling.

Design in Action 143

Ball-bearing memory programs handling sequence—spring-loaded track drives cotton-picking spindles—bang-bang controls guide sub simulator.

Tips and Techniques

Sharpening drawing pencils 129
Lined drawing board 129

Design Abstracts 166

New Parts and Materials 180

Engineering Department Equipment 196

The Engineer's Library 199

Noteworthy Patents 203

Backtalk 222

Helpful Literature 174

Reader Information Service 17
Reprints 201
Advertising Index 219
Business Staff 219

IN THE NEXT ISSUE: Information retrieval . . . pricing new products . . . chemical cleaning of metal parts . . . ball-bearing splines . . . D-C motor control . . . edge-lighted panels . . . flexible-beam suspensions . . . gas-operated mechanism . . . velocity-distance-time.

COLIN CARMICHAEL, Editor

BENJAMIN L. HUMMEL, Executive Editor
ROBERT L. STEDFELD, Managing Editor

Senior Associate Editors
LEO F. SPECTOR
WILLIAM S. MILLER

Associate Editors
SPENCER R. GRIFFITH
JAMES A. PARKS
MELVIN E. LONG
JESSE W. HUCKERT
CLARE E. WISE
DONALD R. DREGER

Assistant Editors
THEODORE M. LEACH
STANLEY G. COOK
RICHARD A. JACOBSON
SAMUEL E. BARNES
JOSEPH M. HOMITCH
FRANCIS J. LAVOIE
LEONARD B. STANLEY
JANE H. SMITH
MARIAN L. EICHAR

Art Editors
FRANK H. BURGESS
ROBERT L. TUFTS

PUBLISHER
ROBERT L. HARTFORD

EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

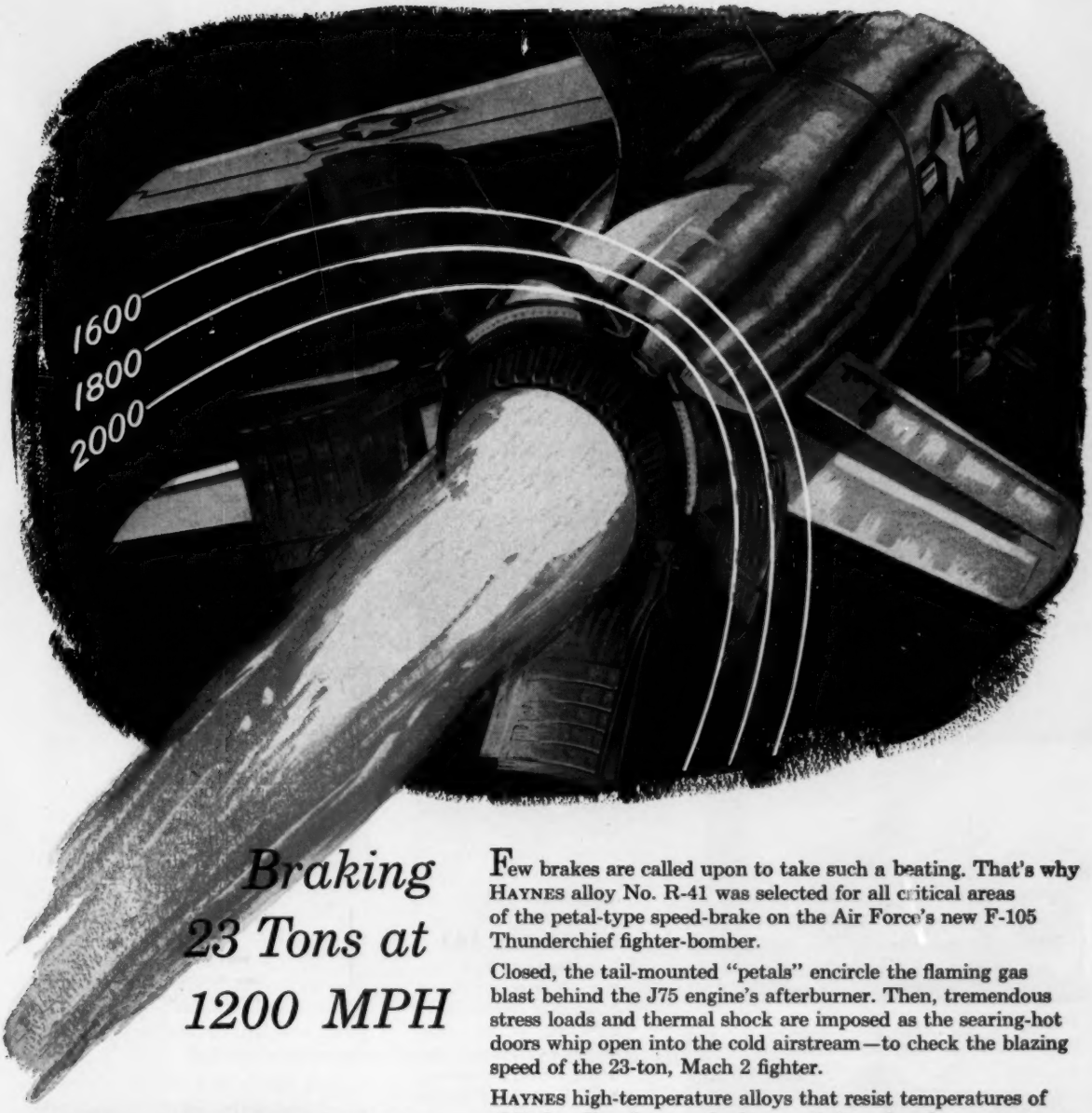
Branch Offices
New York, Detroit, Chicago, Pittsburgh, Washington, London

©1961 by The Penton Publishing Co. All rights reserved.

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.



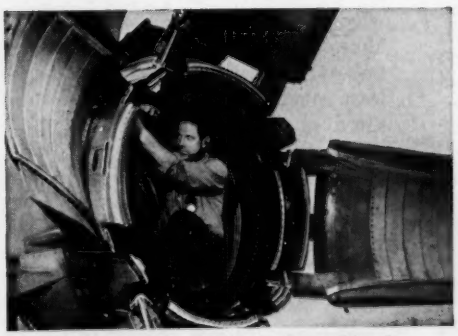
Braking 23 Tons at 1200 MPH

Few brakes are called upon to take such a beating. That's why HAYNES alloy No. R-41 was selected for all critical areas of the petal-type speed-brake on the Air Force's new F-105 Thunderchief fighter-bomber.

Closed, the tail-mounted "petals" encircle the flaming gas blast behind the J75 engine's afterburner. Then, tremendous stress loads and thermal shock are imposed as the searing-hot doors whip open into the cold airstream—to check the blazing speed of the 23-ton, Mach 2 fighter.

HAYNES high-temperature alloys that resist temperatures of 1700 deg. F and over—for long periods and under great stress—today serve many hot spots. Resistance to stress, to thermal shock, to corrosion, erosion, and fatigue, are typical properties that make these alloys so extremely useful in turbojet engines, in ramjets, missiles, rockets, manned space capsules.

Whether investment- or sand-cast, rolled, wrought, vacuum melted, or air melted, there's a HAYNES high-temperature alloy to meet your needs.



Mechanic adjusts hinge of speed-brake door whose critical parts are of HAYNES alloy No. R-41.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

Kokomo, Indiana

UNION CARBIDE

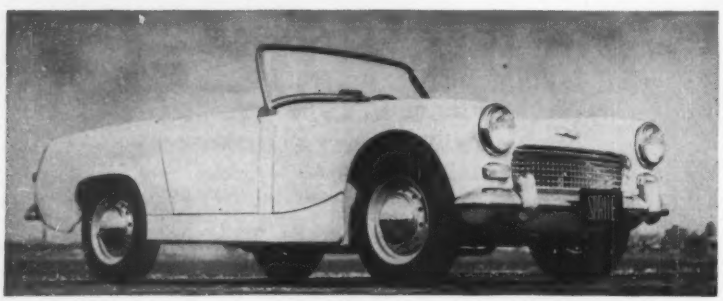
Address inquiries to Haynes Stellite Company, 270 Park Avenue, New York 17, N. Y.

"Haynes" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

A pair of imports:

New-Model MG . . . New-Look Sprite

Strong family resemblance is clearly reflected in rear views of the Sprite Mk. II and MG Midget; styling is practically identical, down to tail lights, bumpers, and gasoline cap. The two cars are also alike underneath. Both are of all steel, mono-construction (integral body-frame), have rack and pinion steering, drum brakes, and use identical suspension systems: front —independent with coil springs and wishbones; rear — quarter-elliptic leaf springs.



NEW YORK—British Motor Corp., manufacturer of more than 50 per cent of all sports cars sold in the U. S. has doubled its selection of "compact" sports models with the introduction of the MG Midget. Production of the new car follows closely the announcement that BMC's popular Austin-Healy Sprite (the other compact) has been given its first face lift in three years.

Sprite's restyling and the introduction of the Midget are evidently not coincidental—the cars are similar mechanically and in appearance. Both are powered by 4-cyl engines rated at near 50 hp, use the same four-speed gear box with hydraulically actuated single-plate dry clutch. Synchromesh is provided in second, third, and top gears, and forward-gear ratios vary from 3.2:1 to 1:1. Under the hood, double valve springs are operated by push rods from a three-bearing camshaft. Engine cooling is accomplished by a pressurized system with an impeller pump and fan; circulation is thermostatically controlled.

Both Sprite and Midget are soft-top two-seaters, have sliding side windows, and are styled remarkably alike. Performance of the new MG was not disclosed, but it probably at least equals that of the Sprite: Top speed of about 85 mph; 35 mpg.

BMC 948-CC Engine

Type	4-cyl, ohv
Bore & Stroke (in.)	2.47 x 3.00
Displacement (cu in.)	57.9
Compression Ratio	9 to 1
Power, max (bhp)	49.5 @ 5500
Torque, max (lb-ft)	52.5 @ 2750

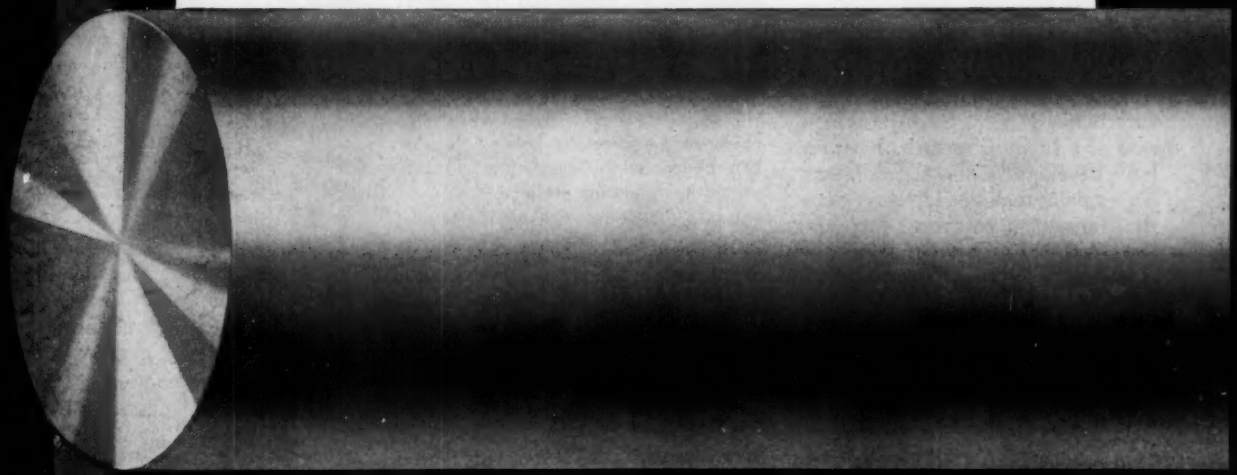
Application tested! Proved!

WHY HEAT TREAT PARTS? use e.t.d. 150

elevated temperature drawing (150,000 psi tensile)

ALLOY STEEL BARS

- **e.t.d. 150 Alloy needs no heat treating!**
- **e.t.d. 150 Alloy has 150,000 psi tensile guaranteed! (Rockwell C32 minimum)**
- **e.t.d. 150 Alloy machines better than heat treated alloy steels!**



Here are cost-reducing advantages

(1) Heat treating problems, costs (and secondary operations) are eliminated. (2) "e.t.d." 150 machines better than heat treated in-the-bar alloy steels. (3) Tool life and finish are excellent. (4) No quench cracks or distortion from heat treatment. (5) "e.t.d." 150 has exceptional strength and hardness uniformity across the bar. (6) End cost of parts is greatly reduced.

Use this coupon to request Helpful Data Bulletin 22.

La Salle STEEL CO.

1426 150th St. Hammond, Ind.

Manufacturers of STRESSPROOF®, FATIGUE-PROOF®, and a complete line of cold-finished steel bars.

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

Available from your Steel Service Center

Circle 207 on Page 19

'Peek-a-boo' Cards Dial NBS Information Drum

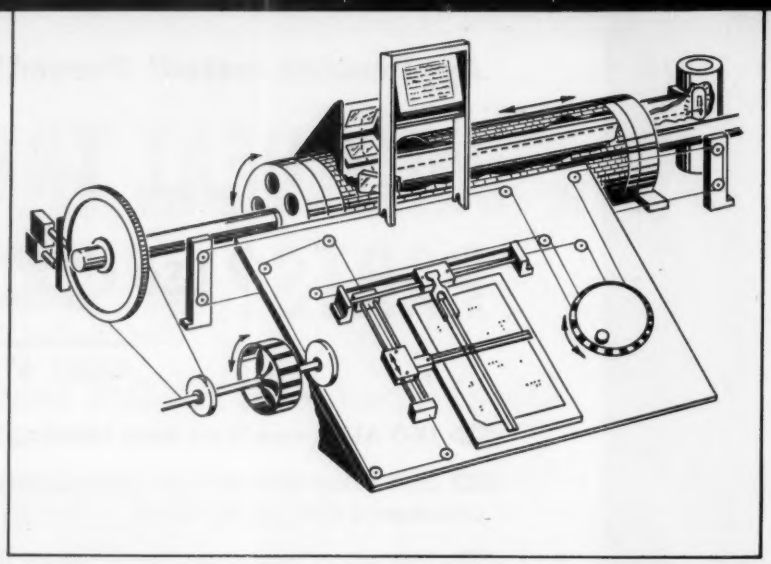
WASHINGTON — A punched-card technique called peek-a-boo and a newly developed electromechanical searching machine are helping the National Bureau of Standards researchers do their own reference work. Simplicity of the equipment, coupled with a number of automatic features, allows each man to do his own "digging."

Most of the current work in the information-retrieval area is directed toward development of complex machines with vast memories. But after the inquirer has supplied the input to these machines, he will lose direct control of the search. The element of feedback is missing.

NBS scientists believe feedback contributes so much to the effectiveness of a literature search that they have developed something different. To explain their stand, they draw the analogy between literature searching and the game of "twenty questions." The game is effective in pinpointing information because each question is phrased after the previous one has been answered. The researcher is at all times in control of the search process and is up to date on information developed.

In the peek-a-boo technique, each of the punched cards represents an index word, and positions of holes in the card identify documents pertaining to the word. When cards representing key words are superimposed, holes that remain unobscured refer to appropriate documents.

The searching machine allows these documents to be viewed. For each index card, there is a corresponding 15-in.-square sheet of film. The film contains abstracts of 18,000 documents, corresponding in location to the 18,000 holes on the card. The searcher mounts the index cards in the machine and mounts the film matrices on a drum of the machine. Then, he adjusts (by control wheels) horizontal and vertical cursors to center on each unobscured hole in turn. Turning the control wheels causes rotation and translation of the drum carrying the film matrix, and as the cursor is set on each hole, a full-size focused image of the abstract corresponding to the hole is projected on a screen.



Driving a simple cable linkage, two control wheels rotate and translate a drum and position cursors over holes in punched cards. Mounted on the drum, a film of microimaged abstracts (positioned according to the card holes) is focused on the screen when the cursors intersect over a hole. Abstracts can be copied by tripping a camera within the machine (right).

Topics

For the price of a fine or two, a heavy-footed motorist can buy a radar detector. A transistorized device about the size of a cigarette pack, it gives warning when a car enters a radar-patrolled zone. Gepco Mfg. Co., Summit, Ill., claims its detector will pick up any radar transmission.

• • •

No ribbon to change and no smudgy erasures are two big advantages of a noiseless typewriter invented by John E. Hickerson, senior engineer for IBM. Instead of the usual letters on bars, the experimental machine has a type wheel. Striking the keys turns this wheel, presenting a letter at a time to an endless magnetic tape. Blown-on powdered ink sticks to the tape, which is then pressed against the paper. A whole line prints at once; it can be inspected beforehand and corrections made by wiping and retyping. After a line is printed, the tape is demagnetized, and the ink is brushed off.

• • •

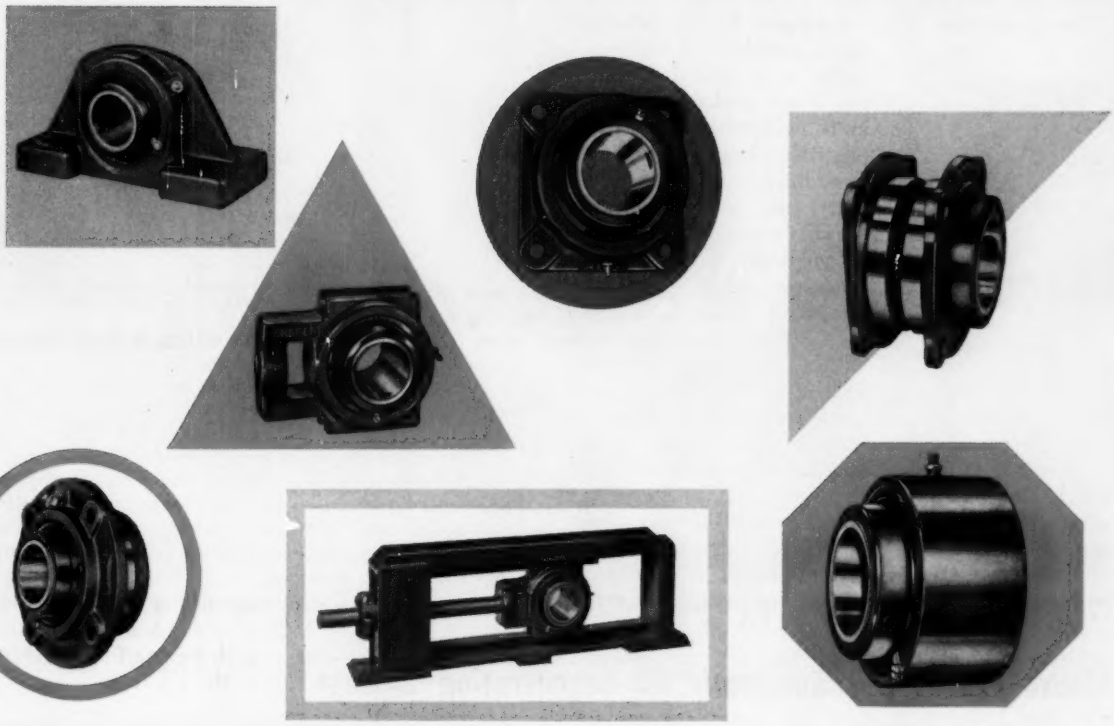
Landing strips will get the brush from Dyna-Soar space gliders when they return from a flight. Goodyear Tire & Rubber Co. is developing wire-brush landing gear skids for the vehicle.

• • •

Green cheese—and any other material the moon is made of—will be analyzed by a miniature chemistry laboratory aboard the Surveyor spacecraft scheduled for a moon landing in 1963. The lunar chromatograph will be set up to study organic chemicals, found recently in meteorites and suggesting life on other planets. Gases released by heating lunar soil will be piped into a "super sniffer," where chemical composition will be determined by passing a minute electrical current through the gas. Information on any of several hundred compounds will be converted into electrical signals and transmitted to earth. The chromatograph, under development by Aerojet-General Corp. for NASA, will be contained in an 8 by 8 by 10-in. black box.

greatest variety

lets you select the housing that's best



Why use costly specials? Why substitute? With Shafer-Rex you can select the one housing that's best for your specific requirements.

The Shafer-Rex line of mounted roller bearings is the most complete in the industry. You can select from a variety of housing styles—each available with normal-duty, heavy-duty and adapter bearings.

And, style for style, Shafer-Rex saves space. It fits into the tight spots, allowing you maximum freedom of design.

In addition, a Shafer-Rex Self-Aligning Bearing assures long life: eliminates additional wear and stress of misalignment; takes severe shock and loading safely; takes thrust loads without strain or binding.

Write CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wis. In Canada: Rex Chainbelt (Canada) Ltd., Toronto and Montreal.

SHAFER® REX® SELF-ALIGNING ROLLER BEARINGS

Circle 208 on Page 19

Tape-Controlled Gage Catches Errors of 0.00001 in.

DAYTON, OHIO—A 16-ton system, commanded by a roll of punched tape, completes almost 1000 precise measurements necessary on a missile nose cone in two hours. Designed to automate an unusually critical inspection process, the measuring machine checks out a nose cone in a fraction of the time required by other methods (about one month).

The jumbo-size gage, developed by the Sheffield Corp., subsidiary of the Bendix Corp., is so sensitive that it can detect a change as small as 10 millionths of an inch in relatively large components. In addition to speed and sensitivity, the device eliminates human error because it can automatically perform thousands of detailed measurements. If required, it could take 100,000 precision readings on a single inch of the part being inspected. Capable of measuring inside, outside, and thickness dimensions, the machine uses five axes to position and record the position of electronic gaging styli.

According to Louis Polk, Sheffield's chairman of the board, this first measuring system is the forerunner of several machines now being developed for fast, highly accurate tolerance control of key components. The equipment will be used in inspection of commercial products as well as in space and weapons systems.

Part to be measured rotates on a positioning table while sensing devices feel its inner and outer surfaces. Control and thickness data are typed automatically by the printout unit. The machine can inspect work pieces having diameters up to 20 in.; minimum inside radius of work is 2 in. Operating from instructions coded on a tape, the measurement machine moves the rotary (positioning) table back and forth, slides inner and outer gages up, down, and horizontally. All slides operate within 15 millionths of an inch of true position and can be calibrated to within 10 millionths. According to Sheffield, other measuring devices cannot achieve this accuracy.

Mouse Proves Out Automatic Air-Regeneration System

SUNNYVALE, CALIF.—Locked in a sealed cylinder for 80 hours, a test mouse at Lockheed Missiles and Space Co. recently breathed recycled air supplied by an automatically controlled potassium-superoxide system. Activated as needed, the system used only 100 grams of the superoxide during the test period—one mouse weight for each 20 hours.

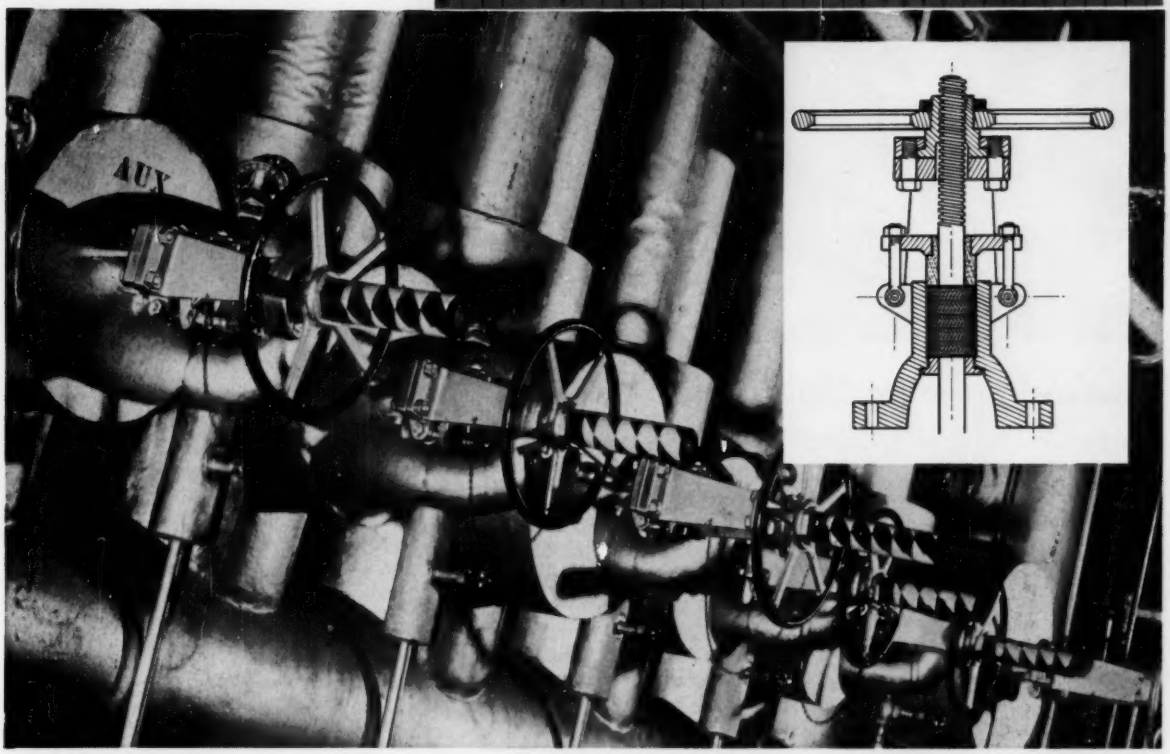
Converting carbon dioxide to oxygen by this process isn't new, but in the past the chemical was manually added to room air when CO_2 gages read high. Many researchers have claimed the superoxide is too unstable for use in automatic life-support systems. They have feared that too much oxygen would be released, creating pressure build-ups which could not be tolerated.

The simplicity of the mouse-tested cell affords a much higher reliability than that of a complicated mechanical system, according to Stan Hall, manager of Lockheed's Bio-Medical Systems Development. The chemical, contained in a cartridge surrounding the cell, is fed through a controlled inlet station at one end. Key component in the system is a precise regulator which bleeds off excess oxygen. Design of the device was dictated by the metabolic rate of the mouse and cell pressure.

Alive after breathing recycled air for 80 hr, a Lockheed mouse proved the feasibility of a new life-support system for man in space. The automatic process is the first to use potassium superoxide to reclaim air from carbon dioxide.

DU PONT

TEFLON®



Packings of asbestos and TEFLON® TFE in 7 steam valves stopped leakage...reduced maintenance...saved $280 per year

CAN YOU AFFORD NOT TO USE TEFLON?

Packings made with TEFLON are your logical and most economical choice whenever severe environmental conditions are encountered, AND in all cases when you want—

... greatly reduced packing maintenance

... reduction of replacement costs

... reduced cylinder and shaft wear

... greater standardization with reduced packing inventories

... the competitive advantage of quality and dependability

If any of these considerations are important to your design, the choice of any other kind of packing material might well be wasteful.

DU PONT
REG. U. S. PAT. OFF.

The packings: asbestos impregnated with a Du Pont TEFLON TFE-fluorocarbon resin. The application: main distribution control valves on the boiler header shown above, handling steam at 150 psi. and 356°F. The performance advantages: the packings do not leak . . . do not need retightening . . . last indefinitely . . . valves turn easily without "persuaders". Unlike oil, grease and graphite additives, which squeeze out and leave a dry, abrasive base, the impregnations of TEFLON make a lasting mechanical bond with the asbestos. The cost savings: average savings per valve of $10 per year on repacking and retightening formerly necessary, and $30 per year formerly lost through leaking steam —a total of $280 per year for the 7 valves.

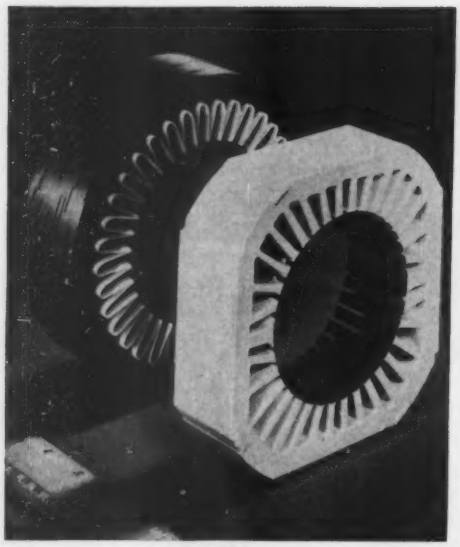
Under more severe service conditions, TEFLON resins are often the only answer. These materials are inert to virtually all chemicals and solvents, at temperatures from −450°F. to 500°F.

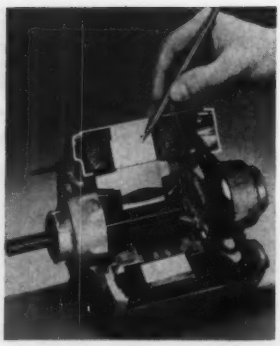
Consult your supplier about the many constructions available in packings made with TEFLON. Write for the new booklets: "Packings for Valves and Pumps", and "Designing with TEFLON". Address: E. I. du Pont de Nemours & Co. (Inc.), Dept. MD-76, Room 2507T, Nemours Building, Wilmington 98, Delaware. **In Canada:** Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

TEFLON®
FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*





Powder bonded to iron will insulate stators on future GE appliance motors. The coating allows use of irregular slot configurations, and stators are much thinner than standard stators with plastic slot liners.

Powdered Insulation Shrinks Small Motors

SCHENECTADY, N. Y. — Stator-slot configurations need no longer limit the flexibility of appliance-motor design. A new insulation powder, bonded directly to the stator iron, allows irregularly shaped, nonuniform slots and permits a better match of a motor to its application.

The insulation system, developed by General Electric Co., Appliance Motor Dept., is already replacing both paper and plastic liners on motors. According to GE, two-speed home-laundry motors will be the first to use the integral powder; all GE appliance motors will eventually use it as production capacity becomes available.

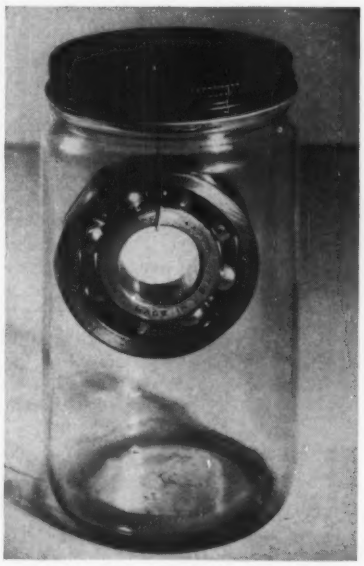
Advantages of the new insulation are tied in to the thinner and irregular slots it makes possible. Motor performance and quality will be improved, and versatility will also increase, says GE. Shorter and lighter two-speed motors are possible, and higher torques from contemporary-size packages will result. In addition, the insulation decreases leakage current and improves moisture resistance and high-temperature life.

Film Stops Rust on Stored Parts

PITTSBURGH — Brushed, sprayed, dipped, or fogged onto ferrous metals, a light oily liquid developed by Ronco Laboratories is said to stop rust completely. High temperature and humidity tests show the preventive works best under adverse conditions.

Intended to protect equipment that must be stored for long periods, the new liquid, called Ferro-Guard, forms a film that seals out dampness and oxygen and neutralizes acids contained in the atmosphere. One coating protects an unwrapped surface for at least a year.

An uncoated bearing (right), suspended for four months over a water-rust preventive mixture and subjected to cyclic-temperature tests, showed no sign of rusting.



Superconducting Transformer Hurdles Design Obstacles

Newest Cryogenic Device Eliminates Winding Losses

CAMBRIDGE, MASS.—A new kind of transformer, now operating successfully at the 15-kw level, may lead to a radical change in power technology. According to its inventor, Dr. Richard McFee, Arthur D. Little Inc., it could be the prototype for lighter and less costly transformers that would not suffer the electrical-heating losses or be subject to temperature limitations of present-day electrical insulation.

Primary Bucks Secondary

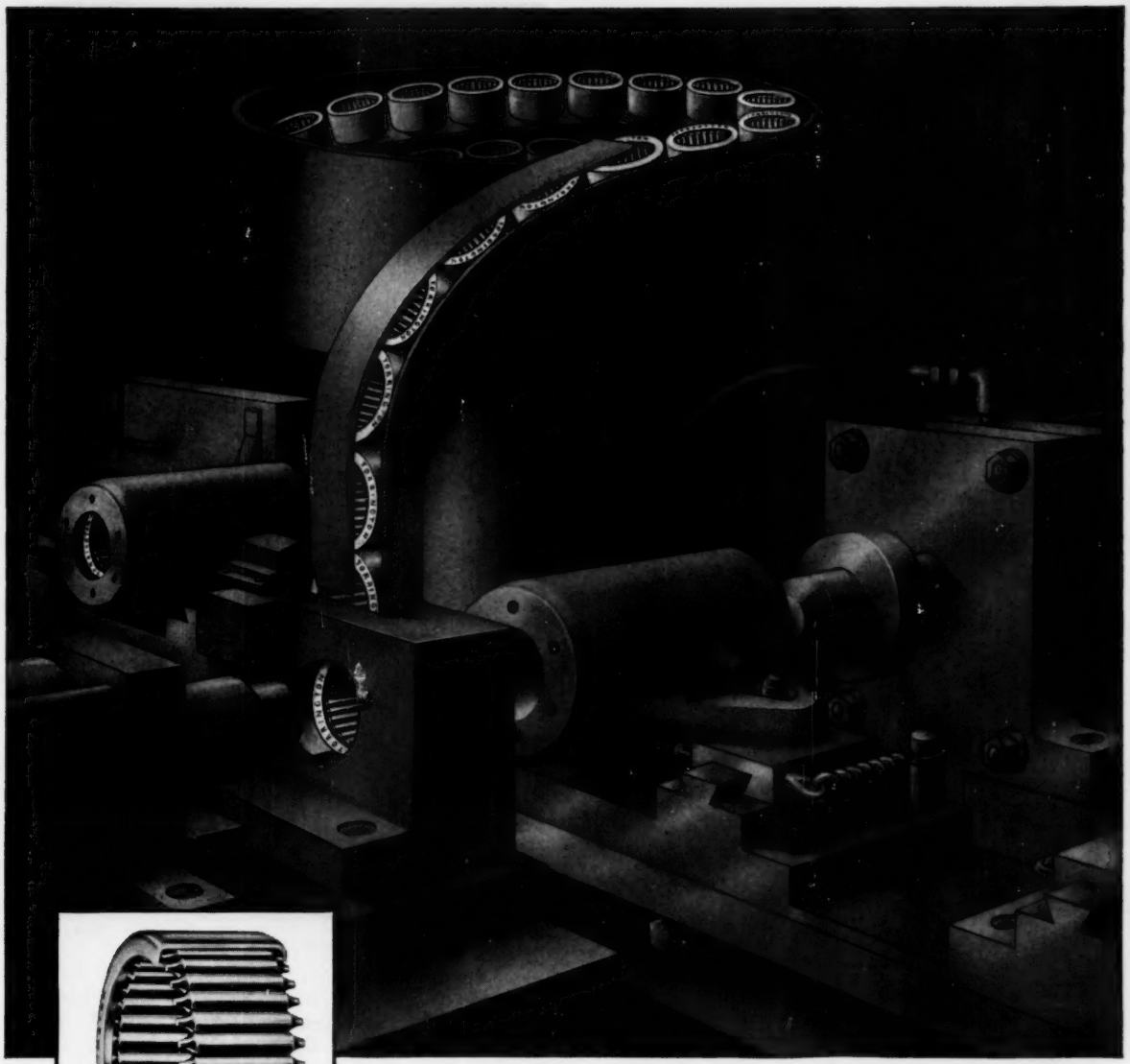
The design makes use of superconductivity—the ability of some metals to conduct an electrical current without resistance at temperatures near absolute zero. Superconducting transformers have been considered before, but magnetic fields above certain trigger strengths quenched the superconducting state. This fact presented apparently insurmountable obstacles. Dr. McFee, however, discovered that by interleaving the layers of primary and secondary windings he could keep the total magnetic-field strength below the critical level. Since current in adjacent layers flows in opposite directions, the individual fields nearly cancel one another.

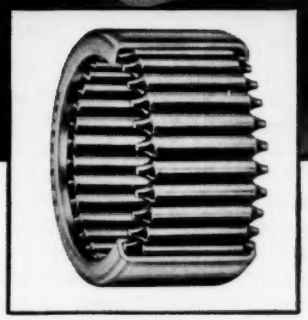
Development of an improved helium refrigerator by ADL solved another problem in the superconducting transformer. Now in its final design stages, the refrigerator will produce temperatures to −452 F and hold them unattended for months of continuous operation.

Only the Coils Are Cooled

Because cost of refrigerating the whole transformer would be excessive, only the superconducting coils are cooled. Heat leaks into the system are controlled by vacuum insulation, liquid - nitrogen heat shields, and arrangement of the superconducting leads.

The problem of excessive current loads requires elaborate safeguards to insure that they don't break down the superconductive state, temporarily putting the device out of service. Outages will be prevented by fast-acting circuit breakers or external inductance coils.





TORRINGTON NEEDLE BEARINGS FEATURE:

- ☐ Unique unit construction
- ☐ Full complement of retained rollers
- ☐ Unequalled radial-load capacity
- ☐ Low coefficient of starting and running friction
- ☐ Low unit cost
- ☐ Long service life
- ☐ Compactness and light weight
- ☐ Run directly on hardened shafts
- ☐ Permit use of larger and stiffer shafts

It's easy as 1–2–3 with . . .

LOW-COST TORRINGTON NEEDLE BEARINGS! They can be installed easier and faster than any other type of anti-friction bearing. There's no waste time . . . no waste motion. No collars, shoulders or retaining rings to complicate assembly. Just one quick ram stroke . . . and the Torrington Needle Bearing is completely and firmly installed.

These exceptionally low-unit-cost and assembly advantages are yours whether you're geared for large volume, high-speed runs on automated machines . . . or lower volume, lower-speed assembly on simple arbor presses. Either way, you'll find it pays to specify Torrington Needle Bearings.

Torrington Needle Bearings offer other outstanding design and performance benefits. For details on how they can help you, call or write us today.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

Vehicle Designs Win Two Awards

CHICAGO—Designs for aluminum vehicles took two awards in Alcoa's industrial design competition for college students. Six winners for 1961 were announced by Aluminum Co. of America.

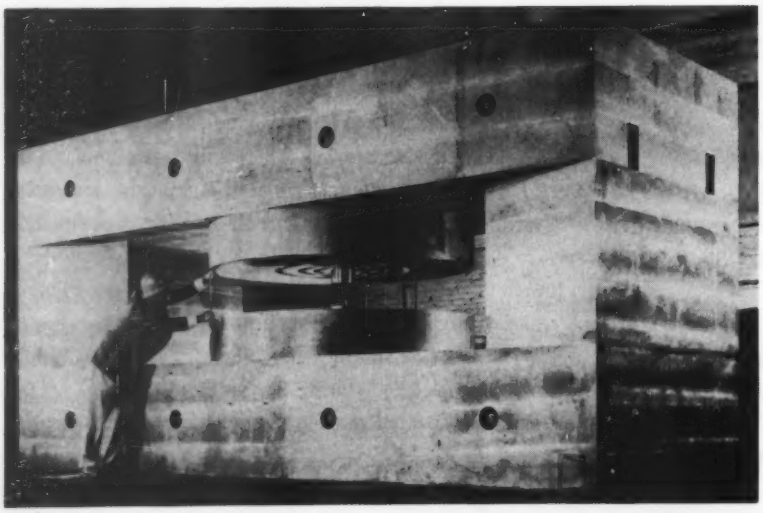
Sparky, an electric runabout (upper photo) designed by Marnie G. Averitt, Illinois Institute of Technology, travels 60 miles at speeds up to 30 mph on one battery charging. Able to carry two people comfortably in its cabin, the vehicle hauls an 800-lb payload or two additional people (seated on a fold-out rumble seat) in the rear deck. Minimum weight is achieved in the all-aluminum body by use of 5052 alloy, formed in aircraft-type panels.

Amphicar, a combination station wagon, boat, and travel trailer (lower photo) designed by John H. Bowers Jr., Pratt Institute, serves five persons comfortably and effectively. Measuring 16 ft long by 7 ft high, with a 7-ft beam and 105-in. wheelbase, it has a loaded weight of 3000 lb. Cruising speed on land is 60 mph; in water, 5 knots.

A double-top umbrella roof raises and lowers hydraulically to fit the Amphicar for its three functions. With roof lowered and "penthouse" raised, it has 74 in. of headroom for camping. With roof raised for boating, headroom reaches 77 in.; cab roof serves as a sundeck and driving platform.

The other four awards were given for an overhead transportation complex (David L. Haas, University of Bridgeport), a fastening technique (Andrew A. Oakes, Philadelphia Museum College of Art), a mail box (Robert C. Taylor, University of Illinois), and a ski and pole storage-carrier (Charles Tipple, Syracuse).

For Smashing Atoms: Precision by the Ton



The fourteen forgings making up the magnet fit together with tolerances of 0.006 in., although the smallest block weighs 12 tons. Frame of the magnet measures 20 ft long, 7 ft wide, and 9½ ft high.

BERKELEY, CALIF. — Fourteen massive blocks of precision-shaped steel make up the magnet core in the University of California's new atom smasher. Forged and machined by United States Steel Corp., the 275-ton magnet will provide the 88-in. cyclotron with a very high beam current—about 10^{13} particles per sec.

The atom smasher, a new design, is not intended to accelerate particles to very high velocities. It will, however, have unmatched versatility. The million billion particles accelerated every second should permit nuclear explorations never before possible. The beam current is about double that of the famous 60-in. Berkeley cyclotron; about 1000 times that of the 184-in. machine.

150,000-mph Particles May Trigger Spaceship Explosion

Tests Show Vaporific Blasts Possible Danger to Crew

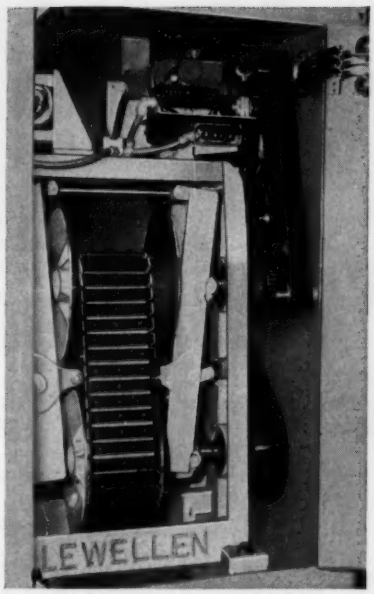
DALLAS — The space crewman whose craft is pierced by a fast-moving micrometeoroid may face the danger of a "vaporific effect" similar to a flash explosion. According to Dr. Charles F. Gell, director of life sciences, Chance Vought Aircraft Inc., Astronautics Div., the likelihood of an astronaut in the Mercury capsule or Dyna-Soar vehicle being struck is not great, but the problem must be solved before long flights can be safely attempted.

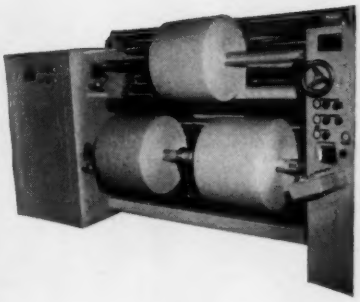
When researchers fired 0.2-gram aluminum pellets through a vacuum at an air-filled chamber, cameras recorded bright explosion - like flashes inside the chamber. Later, traces of aluminum oxide were found. Velocity of the pellets (17,000 mph) was well below the average velocity of micrometeoroids —believed to be near 150,000 mph —but it did approach the speed of the slowest particles.

Mice and Meteoroids

Six experiments were conducted with mice in the simulated space ship. In five of the tests, the animals, in a normal atmosphere, suffered varying degrees of injuries and burns and appeared to be in shock. Four of the five recovered. In the final test, oxygen content of the atmosphere was boosted to 90-95 per cent. The results were catastrophic. The mouse died instantly and was totally charred in the explosion. Microscopic examination showed extensive lung damage.

Before these tests, scientists had assumed that small-meteoroid punctures would cause slow leakage from the cabin, a problem which a crewman in a full-pressure suit could handle with patching. "The posibility of intense heat, light, and blast accompanying such a penetration now suggests an unsuspected danger," reports Dr. Gell. The average space ship is likely to have an outer skin 0.1-in. thick, and tests show that even if only the outer skin is penetrated the vaporific effect occurs. An explosion between layers could carry into the cabin if measures aren't taken.





LEWELLEN V/S TRANSMISSION VARIES SPEEDS AUTOMATICALLY CONTROLS TENSION PRECISELY

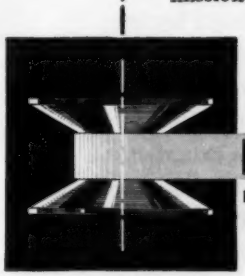
This Dusenbery Model 815 Slitter-Rewinder incorporates the LEWELLEN V/S Transmission to drive the rewind mandrels. Mandrel speeds slow automatically as the rewind rolls fill.

The Dusenbery Slitter-Rewinder processes fine caliper polymer films at speeds to 1500 f.p.m. Precise tension control is essential.

Variable speeds at the LEWELLEN are so finely adjustable and precisely stable that control is maintained continuously.

The Slitter-Rewinder stops for reloading. During this interval the V/S Transmission resets—while not running—to the mandrel fast starting speed.

If YOUR requirements are exacting, compare the features that the LEWELLEN V/S Transmission offers.



Write for Catalog 65

LEWELLEN

Manufacturing Company, Columbus, Indiana

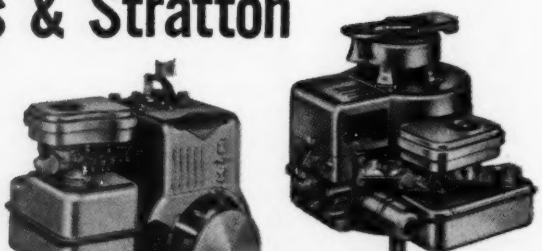
Distributors in all Industrial Areas

Circle 211 on Page 19

this is the time
to talk engines
Generator Set
req'd = 1000 watts, 50 cycles
for 2 pole - rpm = 50 x 2 x 60 / 2 = 3000
for 4 pole = 50 x 2 x 60 / 4
assume generator efficiency 70%
engine watts output = 1000 / 70 x 100 = 1430
engine horsepower output = 1430 / 746
engine rating, allowance for temp
altitude, cylinder head deposits,
allow 25%
engine rating = 1.92 / .75 = 2.57
80200 rating at 3000 rpm 2.74
check - max. rec. hp at 3000 2.24
O.K.

before you start your designing... start planning with Briggs & Stratton

NEW PRODUCT IDEAS in the works? A suggestion — when you start your power equipment design layouts, use the detailed Engine Specifications available from Briggs & Stratton. Also available is Briggs & Stratton's Consulting Engineering Service with almost four decades of small engine power application experience. Write or phone Hugh S. Brown, Engineering Vice President, Briggs & Stratton Corp., Milwaukee 1, Wisconsin. (Phone LOcust 2-5000)



Vertical and horizontal crankshaft models—2 to 9 hp

4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES

Most respected name in power

Circle 212 on Page 19

Reader Information Service

Circle number on Yellow Card for

- Free catalogs, bulletins, literature
- Information about new parts, materials
- Design data on advertised products
- Extra copies of editorial articles

HELPFUL LITERATURE

Descriptions of items start on Page 174. Starred items are from June 22 issue.

Electrical, Electronic

505 Low-Voltage Switchgear. 20 pp. I-T-E Circuit Breaker Co.

507 Digital Totalizers. 4 pp. Potter Aeronautical Corp.

508 Industrial Switches. 12 pp. R. B. Denison Mfg. Co.

511 Semiconductor Reliability. Semiconductor Div., Raytheon Co.

520 Electromechanical Devices. 20 pp. Autotronics Inc.

524 Photocathode Characteristics. ITT Federal Laboratories.

525 Temperature Transducers. 4 pp. Trans-Sonics Inc.

526 Selsyn Indicating Systems. 6 pp. General Electric Co.

527 Fractional-Horsepower Motors. 4 pp. Industrial Motor Dept., Westinghouse Electric Corp.

528 Vibration Inducers. 6 pp. Martin Engineering Co.

531 Transistor Heat Dissipators. 4 pp. U. S. Heat Sink.

533 Indicators, Controllers. 4 pp. Thermo Electric Co. Inc.

571 Range Drives.* Application of Varidyne ac controlled speed systems to range drives. Brochure F-2028, 6 pp. U. S. Electrical Motors Inc.

572 Silicon Rectifiers.* Description of over 150 different units. 6 pp. Semiconductor Div., Raytheon Co.

573 Thermometers and Gages.* Ten standard models in scale ranges from −150 to +1000 F. Bulletin 282, 4 pp. Controls Div., American-Standard.

574 Electric Motors.* Covers ½ to 600-hp motors. Catalog BMC-914, 12 pp. Brook Motor Corp.

575 Control Instruments.* Data on instruments for various control applications. 26 pp. Moore Products Co.

576 Glass-Sealed Resistors.* RX and Hi-Meg units are described. Bulletin 3140-61, 4 pp. Victoreen Instrument Co.

577 Control Switches.* Data on switches, flow meters, manometers, air-filter gages. 30 pp. Henry G. Dietz Co. Inc.

578 Metal-Clad Switchgear.* Units range from 2.4 to 13.8 kv; 75 to 1000 mva. Bulletin GEA-5664F, 42 pp. General Electric Co.

579 Printed-Board Connectors.* Pos-E-Kon units for flat conductor cable and flexible etched circuitry. Bulletin P2-39, 4 pp. Pos-E-Kon Div., Thomas & Betts Co. Inc.

Hydraulic, Pneumatic

504 Pressure, Vacuum Gage. 32 pp. Helicoid Gage Div., American Chain & Cable Co. Inc.

506 Process Pumps. 8 pp. Byron Jackson Pumps Inc.

512 Gate, Globe, Check Valves. 16 pp. R-P & C Valve Div., American Chain & Cable Co. Inc.

516 Solenoid Valve Selection. 16 pp. Valcor Engineering Corp.

519 Chemical Pumps. 8 pp. Ingersoll-Rand Co.

521 Insulating Sleeving. 4 pp. L. Frank Markel & Sons.

529 Agitation-Equipment Drive. 8 pp. Pfaudler Co.

530 Diaphragm Valves. 6 pp. Hills-McCanna Co.

534 Lightweight Fittings. 8 pp. Harrison Mfg. Co.

580 Liquid-Level-Gage Valves.* Union-Bonnet and screwed-bonnet types. Catalogs 397 and 398, 8 pp. Jerguson Gage & Valve Co.

581 Centrifugal Pumps.* Type GP close-coupled, end-suction pumps. Bulletin 117PKG, 4 pp. Aurora Pump Div., New York Air Brake Co.

582 Hydraulic Products.* Describes miniaturized hydraulic pump, in 96 models, plus other products. Catalog 21, 76 pp. Oil-Dyne Inc.

583 Plugs, Chip Detectors, Valves.* Where the units can be used, what they do. Catalog MPC-61, 26 pp. Lisle Corp.

584 Rotating Seal.* Type 605 for use in pumps, compressors, agitators, mixers. Bulletin M102, 4 pp. Sealol Inc.

585 Bellows, Bellows Assemblies.* Data on Formweld and Formflex units. Catalog 610, 20 pp. Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co.

586 Miniature Check Valves.* For use in fuel, hydraulic, and chemical systems. Catalog 608, 30 pp. Spartan Mfg. Co.

587 Small Pumps.* With capacities to 50 gpm for pressures to 350 psig. Bulletin 150.4, 4 pp. Moyno Pump Div., Robbins & Myers Inc.

588 Plastic Protectors.* Threaded acetate-plastic units for male and female machine screws and pipe threads. Bulletin 6104-AP, 8 pp. S. S. White Plastics Div.

589 Pressure Snubbers.* Porous-metal snubbers for pressure-instrument protection. 4 pp. Chemiquip Co.

590 Pump Drives.* Ratings, specifications, thrust capacities, speeds, selection charts. Brochure F-2002, 20 pages. U. S. Electrical Motors Inc.

591 Valves, Cylinders, Pumps.* Data on Tube-O-Matic control valve, plus other units. Bulletin 91051, 6 pp. Airmatic Valve Inc.

592 Variable-Displacement Pump.* WO-7 high-pressure, piston-type pump. Catalog WO-7, 4 pp. Hydraulic & Pneumatic Sales, Weatherhead Co.

593 Electric Valve.* Series B miniature valve with 1-in. diameter. Bulletin D15.1.1, 4 pp. Skinner Electric Valve Div., Skinner Precision Industries Inc.

594 Sight-Flow Indicator.* Brooksight indicator has no blind threads. Bulletin 820, 4 pp. Brooks Instrument Co.

Mechanical Equipment

509 Shaft Key. 4 pp. Sure-Lok Co.

515 Differentials and Gears. 4 pp. Instru-Lec Corp.

523 Pillow Blocks. 4 pp. Link-Belt Co.

595 Drive Tensioner.* Hi-Q tensioner can be floor, wall, or shaft-mounted. Catalog TR-1, 4 pp. Maurey Mfg. Corp.

596 Shear Pin Sprockets.* Protect equipment against destructive overload. Bulletin 6119P, 8 pp. Chain Belt Co., Milwaukee 1, Wis.

597 Antifriction Bearing Screw.* Roton unit converts rotary force into linear force, motion. About 22 pp. Anderson Co.

598 Power-Transmission Templates.* Permits selection of the correct unit for the application. Crown Gear Co.

599 Self-Lubricated Bearings.* Lube-Align bearings have bronze bearing in aluminum housing. 8 pp. Bronze Bearings Inc.

600 Sleeve Bearings.* Two new types of self-aligning, self-lubricating sleeve bearings. Folder 2823, 6 pp. Link-Belt Co.

601 Roller Chain.* With Delrin top plates. Bulletin 9, 4 pp. Acme Chain Corp.

Assembly Components

502 Medium-Duty Casters. 4 pp. Payson-Harris & Reed Inc.

518 Wire Markers. 2 pp. Stahlin Brothers Inc.

602 Lock-Washer Selection.* Describes correct washer for various applications. Booklet AS-105, 12 pp. Shakeproof Div., Illinois Tool Works.

603 Self-Threading Nuts.* Advantages, operation, dimensional data. Catalog 585A, 8 pp. Palnut Co., Div., United-Carr Fastener Corp.

604 Wire Markers.* E-Z-Code markers are self-laminating. Booklet SL4-3, 4 pp. Westline Products Div., Western Lithograph Co.

605 Multipurpose Fastener.* Nylatch can be used in metal, wood, synthetics. 8 pp. Hartwell Corp.

606 Miniature Stake Nuts.* Floating and non-floating units provide high holding power. 6 pp. Kaylock Div., Kaynar Mfg. Co., Inc.

607 Nuts and Bolts.* Stover lock nut, other nuts and bolts covered. Bulletin 953, 8 pp. Lamson & Sessions Co.

608 Screw-Lock Inserts.* Incorporate a grip-coil to prevent loosening. Bulletin 738-C, 8 pp. Heli-Coil Corp.

Manufacturing Processes, Parts

510 Hot-Dip Galvanized Products. 32 pp. American Hot-Dip Galvanizers Association Inc.

513 Stainless Machining Chart. 2 pp. Peter A. Frasse & Co.

Materials

501 Neoprene Adhesive. 4 pp. Schenectady Varnish Co. Inc.

503 Industrial Felts. 16 pp. Continental Felt Co.

522 Properties of Cast Irons. 6 pp. Hamilton Foundry Inc.

609 Designing with Titanium.* Potentials of sintered titanium in modern design. Bulletin 100, 4 pp. Mechanical Research Div., Clevite Corp.

610 Patterned Steel.* Sharonart surface-rolled

HELPFUL LITERATURE (Cont.)

patterns in stainless, carbon, coated steels. 20 pp. Sharon Steel Corp.

611 **ABS Thermoplastic Resin.*** Cycolac material in 11 formulations. Form 10240, 8 pp. Marbon Chemical Div., Borg-Warner Corp.

612 **Belting Fabric.*** Avisco XL rayon for conveyor and transmission belting fabrics. 12 pp. American Viscose Corp.

Engineering Dept. Equipment

514 **Self-Sticking Tapes.** 26 pp. ACS Tapes Inc.

517 **Decimal Equivalent Chart.** Ohio Seamless Tube Div., Copperweld Steel Co.

532 **Temperature Recording.** 12 pp. Brush Instruments Div., Clevite Corp.

613 **Rotation-Analyzing System.*** Rotan system—angle-encoding transducer and rotational analyzer. Bulletin A-2049, 4 pp. Tectronix Inc.

614 **Electronic Tuning Set.*** Describes four applications using digital time signals. 18 pp. Hallicrafters Co.

615 **Recorder-Reproducer.*** GL-2510 unit operates at tape speeds of 1-7/8 to 60 ips. Bulletin 2510, 4 pp. Consolidated Electrodynamics Corp.

Circle the item number for information on products advertised or described, literature offered, and copies of editorial articles.

NEW PARTS, MATERIALS, ENGINEERING EQUIPMENT

Descriptions start on Page 180.

Electrical, Electronic

543 **Synchronous motor** is two-pole unit of open-end ventilated type. General Electric Co.

544 **Thin switch** has only one stressed metal part. Arco Div., Robertshaw-Fulton Controls Co.

550 **Synchronous motor** has L-shaped variable-pole arm to assure starting. Lake City Inc.

552 **Semiconductor photocell** has light-trigger level of 80 ft-c. Solid State Products Inc.

553 **Miniature indicator lights** consist of replaceable lamp cartridge and mating lamp holder. Industrial Devices Inc.

558 **Miniature mechanisms** for airborne instruments resist vibration and shock. International Instruments Inc.

562 **Control units** are suitable for use with NEMA 7 or 9 pushbutton stations. Gemco Electric Co.

Hydraulic, Pneumatic

539 **Miniature check valve** handles pressures to 20,000 psig and temperatures to 1800 F. Marotta Valve Corp.

545 **Top-entry ball valves** have one-piece body design. Strong.

554 **Solenoid valves** have diam of 1 in. and weigh 5 oz. Skinner Electric Valve Div., Skinner Precision Industries Inc.

559 **Dry-film lubricant** has temperature range of −300 to +1200 F. Alpha-Molykote Corp.

560 **Relief valve** is rated at 10 gpm with relieving pressure to 2000 psi. Kepner Products Co.

564 **Solenoid valves** are automatic, packless, normally closed units. J. D. Gould Co.

Mechanical Equipment

537 **Dual-speed drive** provides positional accuracy of 12 min of arc. Mechanical Products Div., Technology Instrument Corp. of Acton.

538 **Pinions, precision gears** in more than 1000 sizes and varieties. Hiram Jones Electronics.

542 **Speed reducer** transmits up to 0.95 hp at output speed of 85 rpm. Dodge Mfg. Corp.

546 **Screw assembly** incorporates spring-pin preloading. Saginaw Steering Gear Div., General Motors Corp.

556 **Packaged chain, sprockets** for small-space uses. Diamond Chain Co.

561 **Flexible gear coupling** operates at speeds to 5000 rpm. Flexible Coupling Div., Sier-Bath Gear & Pump Co. Inc.

Assembly Components

541 **Coil springs** in over 800 new sizes. Associated Spring Corp.

547 **Vibration-damping devices** reduce resonant amplitudes of vibrating structures. Barry Controls Div., Barry Wright Corp.

549 **Clip nut** in No. 8-32 and 10-32 sizes. Shur-Lok Corp.

551 **Shaft collar** transmits torque and/or thrust loads without keyways. Kolock Products Co.

555 **Lock nut** for applications undergoing severe vibration. MacLean-Fogg Lock Nut Co.

557 **Plastic cable strap** mounts in blind hole. Budwig Mfg. Co.

Materials

535 **Optical lenses** of flat plastic give high performance. Stocker & Yale Inc.

536 **Epoxy pellets** can be made in any shape. Epoxy Products Inc., Div., Joseph Waldman & Sons.

540 **Spray adhesive** is sprayable at pressures of 5 psi. Anchor Adhesives Corp.

548 **Printed-circuit laminate** has high tensile and impact strength. Cimastra Div., Cincinnati Milling Machine Co.

563 **Flexible adhesive** bonds grill cloth to wood, plastic, or metal. Anchor Adhesives Corp.

Engineering Dept. Equipment

565 **Solid-state strain gages** have high output and resolution. Kulite-Bytrex Corp.

566 **Pencils and leads** for use on drafting film. Richard Best Pencil Co. Inc.

567 **X-Y recorders** draw curves automatically from dc electrical information. F. L. Moseley Co.

568 **Cryogenic sensors** measure temperatures as low as −269 C. Primary Sensors Dept. C189, Minneapolis-Honeywell Regulator Co.

569 **Magnetic tape recorder** has speeds of 1.875, 3.75, 7.5, and 15 ips. Aero Data Corp., Div., American Concertone Inc.

570 **Pressure transducers** measure high or low pressures at 600 F. Statham Instruments Inc.

EDITORIAL ARTICLES

Single copies of the following articles are available as long as the supply lasts. Starred items are from previous issues. See Page 201 for other available reprints. Editorial content of MACHINE DESIGN is indexed in the Applied Science Technology Index and the Engineering Index, both available in libraries. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor, Mich.

14-1 **Zeus: The Missile Killer.** Its high price tag has clouded the future of America's most successful missile-hunting missile. (3 pp.)

14-2 **Technical Specifications.** A guide to effective administration and control of technical information. (6 pp.)

14-3 **New Roller-Chain Horsepower Ratings.** Getting the most out of the new horsepower and speed ratings proposed by chain manufacturers. (4 pp.)

14-4 **Preventing Electronic Hot Spots.** Component layout and assembly techniques. (4 pp.)

14-5 **Flexible-Beam Suspensions—Part 1.** How to design a suspension with safe vibration characteristics. (9 pp.)

14-6 **Matching Servovalve and Load.** Principles of single-stage servovalves; analysis of four-way servovalve controlling load cylinder; transfer functions. (6 pp.)

14-7 **Prevent Fatigue Failures—Part 6.** How to relate multiaxial fatigue stresses to a single allowable fatigue stress. (5 pp.)

14-8 **Stepped Shafts and Nonuniform Beams (Data Sheet).** Predicting deflections at any point in a stepped shaft or variable-section beam. (6 pp.)

14-9 **Glasses and Ceramics (Abstract).** A design guide to the properties, applications, and advantages of glasses and ceramics. (3 pp.)

13-2 **How To Sell Ideas.*** Presenting ideas to management; what sales resistance to expect. (5 pp.)

13-3 **High-Pressure Hydraulics.*** Design, safety, cost factors involved in designing or specifying a high-pressure hydraulic system. (7 pp.)

13-4 **Reverted Gear Trains.*** Determining the number of teeth needed to get exact ratios in a reverted gear train. (4 pp.)

13-9 **Four-Bar Mechanisms.*** How to select dimensions for best force conditions by using optimum transmission angle. (4 pp.)

12-4 **Clearance in Rolling Bearings.*** Calculation of probable bearing life for any amount of diametral clearance or preload. (5 pp.)

12-5 **Synchro Systems.*** Advantages and limitations of synchro devices; use and applications. (6 pp.)

12-9 **Least-Squares Lines.*** Techniques for assessing the statistical significance of a line drawn through a series of scattered data points. (8 pp.)

11-2 **Measuring the Engineer.*** Newest methods of aptitude appraisal; procedure for doing the job efficiently. (6 pp.)

11-5 **Seals for Hard Vacuums.*** Design concepts; study results on materials for hard-vacuum, reusable seals. (6 pp.)

10-4 **Push-Pull Controls.*** Available types, selection factors, and design practices. (8 pp.)

10-7 **Hydraulic-System Temperatures.*** Simplified procedure to avoid trial-and-error calculations in predicting maximum temperatures. (4 pp.)

9-6 **Chemically Milled Structures.*** Advantages and disadvantages of chemical milling; design of chemically milled parts. (9 pp.)

9-7 **High-Reduction Hypoids.*** Types and applications; design of sets for ratios from 10:1 to 120:1. (9 pp.)

8-2 **Pressure Regulators.*** Basic principles and types; selection and application. (5 pp.)

8-3 **Elastic-Body Mechanics.*** New principles in using elastic properties of materials to solve design problems. (7 pp.)

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

MACHINE DESIGN July 6, 1961

Do not use this card after Sept. 6, 1961

NAME TITLE

COMPANY PRODUCT MANUFACTURED

ADDRESS CITY ZONE STATE

201	226	251	276	301	326	351	376	401	426	451	476	501	526	551	576	601	626	651	676	701	726	751	776	801	816	831	846
202	227	252	277	302	327	352	377	402	427	452	477	502	527	552	577	602	627	652	677	702	727	752	777	802	817	832	847
203	228	253	278	303	328	353	378	403	428	453	478	503	528	553	578	603	628	653	678	703	728	753	778	803	818	833	848
204	229	254	279	304	329	354	379	404	429	454	479	504	529	554	579	604	629	654	679	704	729	754	779	804	819	834	849
205	230	255	280	305	330	355	380	405	430	455	480	505	530	555	580	605	630	655	680	705	730	755	780	805	820	835	850
206	231	256	281	306	331	356	381	406	431	456	481	506	531	556	581	606	631	656	681	706	731	756	781	806	821	836	851
207	232	257	282	307	332	357	382	407	432	457	482	507	532	557	582	607	632	657	682	707	732	757	782	807	822	837	852
208	233	258	283	308	333	358	383	408	433	458	483	508	533	558	583	608	633	658	683	708	733	758	783	808	823	838	853
209	234	259	284	309	334	359	384	409	434	459	484	509	534	559	584	609	634	659	684	709	734	759	784	809	824	839	854
210	235	260	285	310	335	360	385	410	435	460	485	510	535	560	585	610	635	660	685	710	735	760	785	810	825	840	855
211	236	261	286	311	336	361	386	411	436	461	486	511	536	561	586	611	636	661	686	711	736	761	786	811	826	841	856
212	237	262	287	312	337	362	387	412	437	462	487	512	537	562	587	612	637	662	687	712	737	762	787	812	827	842	857
213	238	263	288	313	338	363	388	413	438	463	488	513	538	563	588	613	638	663	688	713	738	763	788	813	828	843	858
214	239	264	289	314	339	364	389	414	439	464	489	514	539	564	589	614	639	664	689	714	739	764	789	814	829	844	859
215	240	265	290	315	340	365	390	415	440	465	490	515	540	565	590	615	640	665	690	715	740	765	790	815	830	845	860
216	241	266	291	316	341	366	391	416	441	466	491	516	541	566	591	616	641	666	691	716	741	766	791	EDITORIAL ARTICLES			
217	242	267	292	317	342	367	392	417	442	467	492	517	542	567	592	617	642	667	692	717	742	767	792				
218	243	268	293	318	343	368	393	418	443	468	493	518	543	568	593	618	643	668	693	718	743	768	793				
219	244	269	294	319	344	369	394	419	444	469	494	519	544	569	594	619	644	669	694	719	744	769	794	14-1	14-9	11-2	
220	245	270	295	320	345	370	395	420	445	470	495	520	545	570	595	620	645	670	695	720	745	770	795	14-2	13-2	11-5	
																								14-3	13-3	10-4	
221	246	271	296	321	346	371	396	421	446	471	496	521	546	571	596	621	646	671	696	721	746	771	796	14-4	13-4	10-7	
222	247	272	297	322	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697	722	747	772	797	14-5	13-9	9-6	
223	248	273	298	323	348	373	398	423	448	473	498	523	548	573	598	623	648	673	698	723	748	773	798	14-6	12-4	9-7	
224	249	274	299	324	349	374	399	424	449	474	499	524	549	574	599	624	649	674	699	724	749	774	799	14-7	12-5	8-2	
225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	14-8	12-9	8-3	

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

MACHINE DESIGN July 6, 1961

Do not use this card after Sept. 6, 1961

NAME TITLE

COMPANY PRODUCT MANUFACTURED

ADDRESS CITY ZONE STATE

201	226	251	276	301	326	351	376	401	426	451	476	501	526	551	576	601	626	651	676	701	726	751	776	801	816	831	846
202	227	252	277	302	327	352	377	402	427	452	477	502	527	552	577	602	627	652	677	702	727	752	777	802	817	832	847
203	228	253	278	303	328	353	378	403	428	453	478	503	528	553	578	603	628	653	678	703	728	753	778	803	818	833	848
204	229	254	279	304	329	354	379	404	429	454	479	504	529	554	579	604	629	654	679	704	729	754	779	804	819	834	849
205	230	255	280	305	330	355	380	405	430	455	480	505	530	555	580	605	630	655	680	705	730	755	780	805	820	835	850
206	231	256	281	306	331	356	381	406	431	456	481	506	531	556	581	606	631	656	681	706	731	756	781	806	821	836	851
207	232	257	282	307	332	357	382	407	432	457	482	507	532	557	582	607	632	657	682	707	732	757	782	807	822	837	852
208	233	258	283	308	333	358	383	408	433	458	483	508	533	558	583	608	633	658	683	708	733	758	783	808	823	838	853
209	234	259	284	309	334	359	384	409	434	459	484	509	534	559	584	609	634	659	684	709	734	759	784	809	824	839	854
210	235	260	285	310	335	360	385	410	435	460	485	510	535	560	585	610	635	660	685	710	735	760	785	810	825	840	855
211	236	261	286	311	336	361	386	411	436	461	486	511	536	561	586	611	636	661	686	711	736	761	786	811	826	841	856
212	237	262	287	312	337	362	387	412	437	462	487	512	537	562	587	612	637	662	687	712	737	762	787	812	827	842	857
213	238	263	288	313	338	363	388	413	438	463	488	513	538	563	588	613	638	663	688	713	738	763	788	813	828	843	858
214	239	264	289	314	339	364	389	414	439	464	489	514	539	564	589	614	639	664	689	714	739	764	789	814	829	844	859
215	240	265	290	315	340	365	390	415	440	465	490	515	540	565	590	615	640	665	690	715	740	765	790	815	830	845	860
216	241	266	291	316	341	366	391	416	441	466	491	516	541	566	591	616	641	666	691	716	741	766	791	EDITORIAL ARTICLES			
217	242	267	292	317	342	367	392	417	442	467	492	517	542	567	592	617	642	667	692	717	742	767	792				
218	243	268	293	318	343	368	393	418	443	468	493	518	543	568	593	618	643	668	693	718	743	768	793				
219	244	269	294	319	344	369	394	419	444	469	494	519	544	569	594	619	644	669	694	719	744	769	794	14-1	14-9	11-2	
220	245	270	295	320	345	370	395	420	445	470	495	520	545	570	595	620	645	670	695	720	745	770	795	14-2	13-2	11-5	
																								14-3	13-3	10-4	
221	246	271	296	321	346	371	396	421	446	471	496	521	546	571	596	621	646	671	696	721	746	771	796	14-4	13-4	10-7	
222	247	272	297	322	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697	722	747	772	797	14-5	13-9	9-6	
223	248	273	298	323	348	373	398	423	448	473	498	523	548	573	598	623	648	673	698	723	748	773	798	14-6	12-4	9-7	
224	249	274	299	324	349	374	399	424	449	474	499	524	549	574	599	624	649	674	699	724	749	774	799	14-7	12-5	8-2	
225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	14-8	12-9	8-3	

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

MACHINE DESIGN July 6, 1961

Do not use this card after Sept. 6, 1961

NAME TITLE

COMPANY PRODUCT MANUFACTURED

ADDRESS CITY ZONE STATE

201	226	251	276	301	326	351	376	401	426	451	476	501	526	551	576	601	626	651	676	701	726	751	776	801	816	831	846
202	227	252	277	302	327	352	377	402	427	452	477	502	527	552	577	602	627	652	677	702	727	752	777	802	817	832	847
203	228	253	278	303	328	353	378	403	428	453	478	503	528	553	578	603	628	653	678	703	728	753	778	803	818	833	848
204	229	254	279	304	329	354	379	404	429	454	479	504	529	554	579	604	629	654	679	704	729	754	779	804	819	834	849
205	230	255	280	305	330	355	380	405	430	455	480	505	530	555	580	605	630	655	680	705	730	755	780	805	820	835	850
206	231	256	281	306	331	356	381	406	431	456	481	506	531	556	581	606	631	656	681	706	731	756	781	806	821	836	851
207	232	257	282	307	332	357	382	407	432	457	482	507	532	557	582	607	632	657	682	707	732	757	782	807	822	837	852
208	233	258	283	308	333	358	383	408	433	458	483	508	533	558	583	608	633	658	683	708	733	758	783	808	823	838	853
209	234	259	284	309	334	359	384	409	434	459	484	509	534	559	584	609	634	659	684	709	734	759	784	809	824	839	854
210	235	260	285	310	335	360	385	410	435	460	485	510	535	560	585	610	635	660	685	710	735	760	785	810	825	840	855
211	236	261	286	311	336	361	386	411	436	461	486	511	536	561	586	611	636	661	686	711	736	761	786	811	826	841	856
212	237	262	287	312	337	362	387	412	437	462	487	512	537	562	587	612	637	662	687	712	737	762	787	812	827	842	857
213	238	263	288	313	338	363	388	413	438	463	488	513	538	563	588	613	638	663	688	713	738	763	788	813	828	843	858
214	239	264	289	314	339	364	389	414	439	464	489	514	539	564	589	614	639	664	689	714	739	764	789	814	829	844	859
215	240	265	290	315	340	365	390	415	440	465	490	515	540	565	590	615	640	665	690	715	740	765	790	815	830	845	860
216	241	266	291	316	341	366	391	416	441	466	491	516	541	566	591	616	641	666	691	716	741	766	791	EDITORIAL ARTICLES			
217	242	267	292	317	342	367	392	417	442	467	492	517	542	567	592	617	642	667	692	717	742	767	792				
218	243	268	293	318	343	368	393	418	443	468	493	518	543	568	593	618	643	668	693	718	743	768	793				
219	244	269	294	319	344	369	394	419	444	469	494	519	544	569	594	619	644	669	694	719	744	769	794	14-1	14-9	11-2	
220	245	270	295	320	345	370	395	420	445	470	495	520	545	570	595	620	645	670	695	720	745	770	795	14-2	13-2	11-5	
																								14-3	13-3	10-4	
221	246	271	296	321	346	371	396	421	446	471	496	521	546	571	596	621	646	671	696	721	746	771	796	14-4	13-4	10-7	
222	247	272	297	322	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697	722	747	772	797	14-5	13-9	9-6	
223	248	273	298	323	348	373	398	423	448	473	498	523	548	573	598	623	648	673	698	723	748	773	798	14-6	12-4	9-7	
224	249	274	299	324	349	374	399	424	449	474	499	524	549	574	599	624	649	674	699	724	749	774	799	14-7	12-5	8-2	
225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	14-8	12-9	8-3	

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

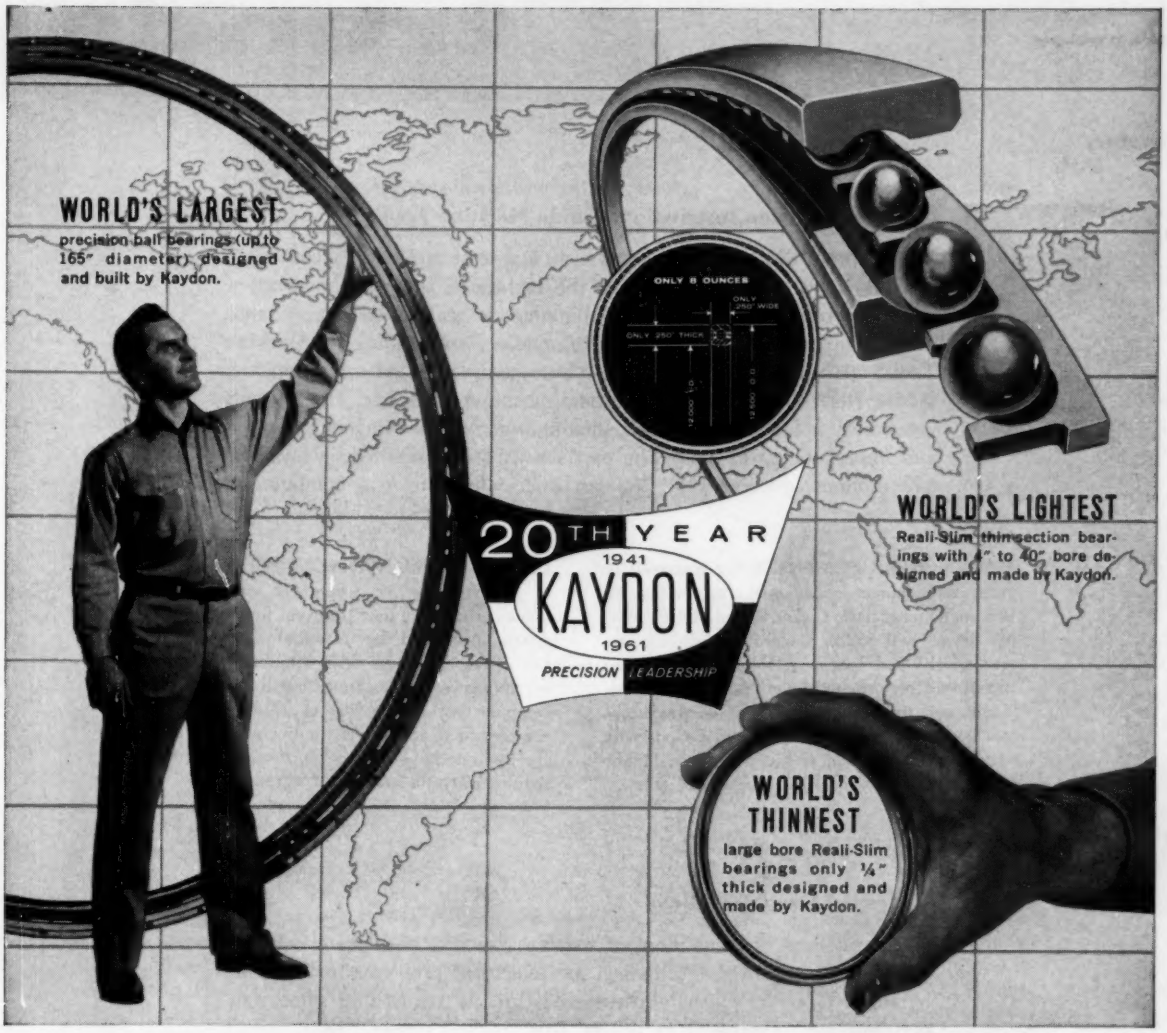
FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.


WORLD'S LARGEST
precision ball bearings (up to 165" diameter) designed and built by Kaydon.
ONLY 8 OUNCES
ONLY .250" THICK
ONLY .250" WIDE
20TH YEAR
1941
KAYDON
1961
PRECISION LEADERSHIP
WORLD'S LIGHTEST
Reali-Slim thin-section bearings with 4" to 40" bore designed and made by Kaydon.
WORLD'S THINNEST
large bore Reali-Slim bearings only ¼" thick designed and made by Kaydon.

Our specialty . . . solving the world's toughest bearing problems

When stock bearings "won't do"... KAYDON special bearings "will"

Standard bearings often aren't adequate when you run up against a combination of limitations involving bearing capacity, size, weight, configuration, material and price.

Solve these problems with Kaydon special bearings—specifically designed and precision-manufactured to do extraordinary jobs.

Kaydon special bearings offer you wide opportunities for compact design that may reduce the size of the equipment you need — providing substantial savings.

Kaydon builds your special bearings with close-tolerance precision, exceptional thrust or radial capacity . . . out of special metals or materials.

Don't penalize performance, or rule out new concepts in design, with stock bearings that "won't do." Call on Kaydon's long experience in design of special bearings that *will* solve your toughest problem.

Available! Reali-Slim type "CP" bearings off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new one-piece snapover bronze separator in 4" to 12" bore — ¼" to 1" width and cross section.

K-611

THE KAYDON ENGINEERING CORP.

• MUSKEGON, MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

World's highest capacity, lowest cost needle bearings (22 sizes available).

Circle 213 on Page 19

trends

computers

English-Language Instructions Guide Machine Tool

With a new IBM programming system, a user of numerically controlled machine tools need only describe the surface of the part he wants—it isn't necessary to spell out tool paths for each operation. A computer controlled by Autopromt (Automatic Programming of Machine Tools) will do this when it is fed information on the part (e.g., sphere, saddle, etc.), tool sizes, tolerances, and machining methods. The system's vocabulary is 110 English words, such as *angle, axis point, cone, cylinder, and hyperbolic paraboloid.* The part shown at left was formed by 8000 tool motions, generated by 180 one-line statements to a computer.

A MOLECULAR COMPUTER for spacecraft is under development at the air arm division of Westinghouse Electric Corp. Called Mol-E-Com, the device will utilize molecular electronics to save weight and space. A solid semiconductor crystal will perform the functions of tubes, transistors, and resistors. A conventional transistorized computer weighs 175 lb; Mol-E-Com will weigh only 15 lb and is expected to be highly reliable because of its small number of parts.

DAY-TO-DAY MANPOWER REQUIREMENTS of the Strategic Air Command will be made known and assignments given by a computer system developed by National Cash Register Co. Every 24 hours SAC will receive a report on manpower needs throughout the world. The computer will search files of 200,000 personnel, consider facts about every individual, and select the best one for a certain job. It will also project requirements six months in advance.

materials

Upgraded Graphite Alloys

A new method of combining, or wetting, graphite with metal will impart greatly improved mechanical and electrical properties to the combination. Graphite's usual brittleness is greatly reduced in some compositions and eliminated in others. Iron, nickel, copper, silver, cobalt, and alloys of these materials can be used in combinations varying from 90 to 10 per cent graphite. Ford Motor Co. developed the process, and Dixon Sintaloy Inc. has the exclusive license to produce the materials for sale in the U. S.

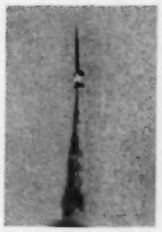
Ceramic-Metal Coating Graduates from the Lab

Introduced last fall as a "laboratory development," a family of temperature resistant ceramic-metal composites is now available on a limited production basis. The material is Nucerite, a combination of ceramic and metal crystals physically and chemically bonded to any of a variety of structural substrate metals. It resists corrosive attack in the 500 to 1500-F range and also possesses mechanical strength, thermal shock resistance, abrasion and erosion resistance, heat conductance, and high temperature stability, according to its developer, the Pfaudler Co.

MODIFIED SAFETY GLASS for windshields has been approved by the British Standards Institution. Reason for changing the standard is that laminated glass designed to fracture into very small pieces can "frost," dangerously reducing visibility. British automakers may now use glass with a "somewhat less toughened" section in front of the driver.

5000-PSI BOND TO ALUMINUM is provided by an epoxy adhesive, Conap 1222, developed by Conap Inc., Allegany, N. Y. Other advantages listed for the new adhesive are exceptional adhesion to steel, copper, glass, and porcelain; toughness; and excellent ductility. It will retain adhesion at temperatures from −65 to 225 F and withstand 30 days' immersion in water.

Air Force Imports Extraterrestrial Dust



To obtain dust from outside the earth's atmosphere, the Air Force sent up an Aerobee-Hi sounding rocket with a special nose cone designed by Aerojet-General Corp. to act as a space vacuum cleaner. At an altitude of 40 miles, leaves holding tiny boxes extended to trap dust particles. The rocket rose to 105 miles; when it dropped back, the leaves retracted before the nose cone separated and was recovered. Air Force scientists hope to learn the characteristics of space dust that distinguish it from the earthly variety and establish a means for observing it from ground stations.

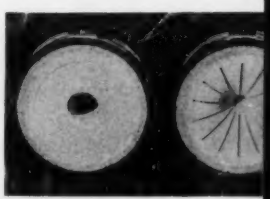
Progress on Apollo

NASA has invited four companies to submit detailed proposals on design, development, and production of the Saturn S-II stage. This will be the second stage of the advanced Saturn and—with its thrust of 800,000 lb—will be able to lift the three-man Apollo spacecraft to escape velocity. Target date for the first flight is late 1964 or early 1965. The four companies are Aerojet-General Corp., Douglas Aircraft Corp., General Dynamics-Astronautics Div., and North American Aviation Inc.

MANAGEMENT TRAINING for engineers is advocated by Sir Frank Whittle, England's famed jet engine designer. In a recent interview, Sir Frank also said that people are beginning to realize that best results will be obtained if "someone at the head of affairs has engineering knowledge. . . . After all, you can't put things right unless you come to a correct conclusion about what causes them to go wrong."

ACCELERATED RECRUITING by the National Aeronautics and Space Administration anticipates manpower requirements of an expanded space exploration program, also is aimed at filling existing vacancies. Recruiting teams at NASA field centers will interview recent college graduates as well as experienced engineers and scientists. Last year, NASA interviewed nearly 3000 persons at 100 colleges.

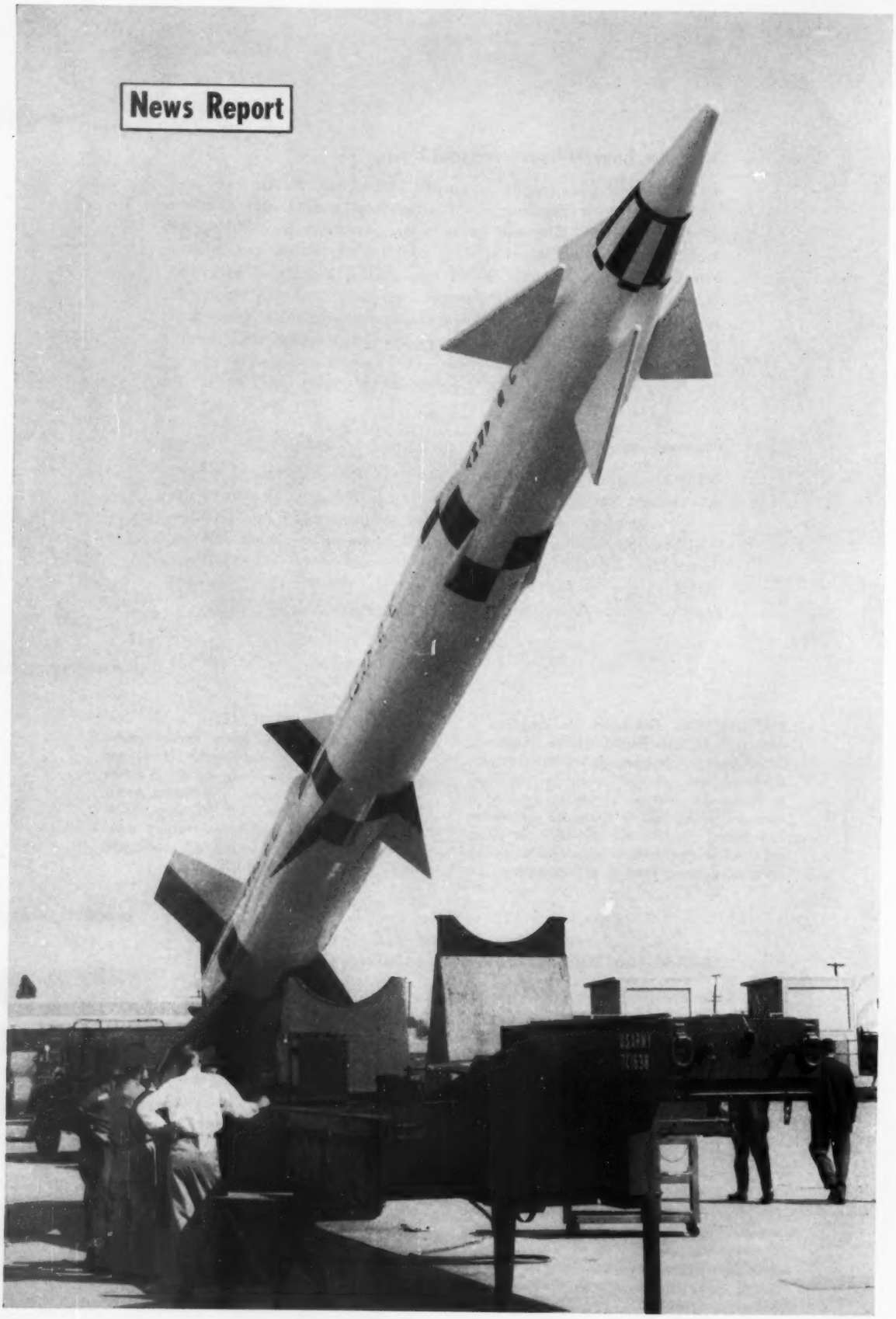
Mold-Making Method Cuts Precision Castings Cost



A development in mold making that permits mass production of precision metal castings at low cost is announced by the Shaw Process Div. of Avnet Electronics Corp. The Shaw process was converted from a "specialty" casting method by a composite mold (sample, right) consisting of a low-cost sand backing with a special ceramic facing, both reclaimable. Previously a solid ceramic mold was used. Also, "bakeout" has been reduced from four or five hours to a matter of minutes.

WEIGHT REDUCTION in cast-iron engine components results from a new precision molding technique announced by the Engine and Foundry Div. of Ford Motor Co. Improved resin bonding for cores and faster core curing permit closer control of wall thickness. The technique is being used for Falcon and Comet engines, will also be used on 1962 Fords.

POWDER METALLURGY PROCESS for Zircaloy 2 provides finished or semifinished shapes which require only light machining. Even special shapes can be held to close tolerances, says General Electric Co. in announcing the new process. Zircaloy 2 is a zirconium-base alloy with a number of properties that make it suitable for the nuclear industry.



Nike Zeus: Uncertain Fate of a

Missile Killer

NIKE Zeus, the only antimissile weapon known to be under active development, is in a state of suspended animation . . . its fate is being debated in Congress, among military leaders, and in industry.

These are the factors that make Zeus controversial:

• Many authorities in the relatively new field of missiie defense don't think a terminal defensive weapon, based on antiaircraft techniques, will be highly effective against an 18,000-mph target. The argument goes on that there "must be a better way."

• Expensive, by any standards, Zeus will cost somewhere between $8 and $15 billion fully installed in the U. S. The $8 billion figure is the latest estimate, based on recent "cost breakthroughs."

On the postive side:

• Zeus is *not* a brand new, untried weapon, but is a product of orderly evolution, its predecessors being Nike Hercules and Nike Ajax. The same industry team has worked on all three projects.

• In no other missile project has confidence of success been at a higher level. Despite the enormous complexities of the weapon and its support equipment, people connected with Zeus will say, with absolutely no hedging, that it will shoot down ICBM warheads like fish in a barrel.

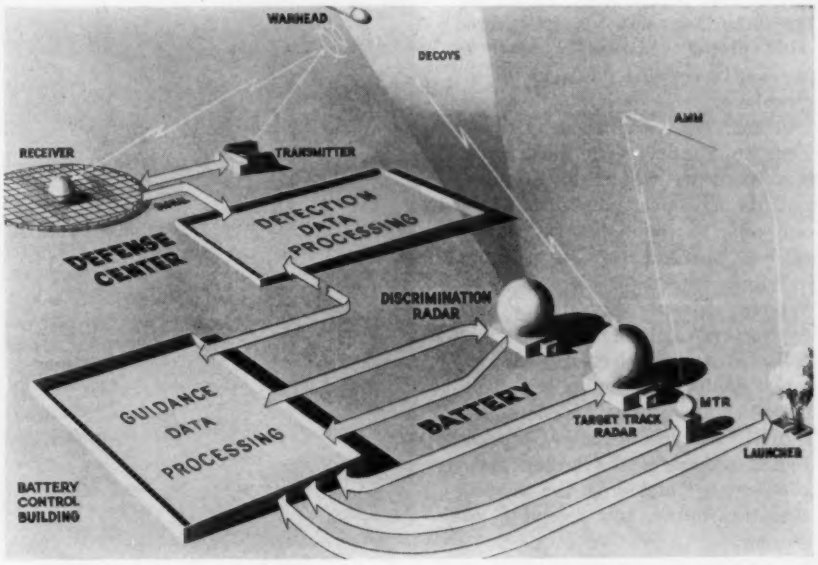
The Army, which is responsible for Zeus, continues to spend huge sums of money on the weapon and has nursed it to a state of development where full-scale production could begin almost immediately if the word were given. Lt. Gen. Arthur Trudea, chief of Army R & D, has answered critics of the Zeus program with this statement: "If we want a missile defense system in this decade, Zeus is the only answer known to the Free World. I would like to hit enemy ICBM's on the launching pad. I'd like to hit them as they come out the factory door. But today, Zeus is the only practical answer."

The Zeus debate will either cool off completely or get considerably hotter early next year when effectiveness of the weapon will be thoroughly proved. Nike Zeus missiles based on Kwajalein Island in the Pacific, will be pitted against Atlas ICBM warheads fired 5000 mi across the ocean from Vandenberg Air Base, Calif. Characteristically, the program is an expensive one. Eighteen Atlas missiles are reportedly on order for the tests, and General Electric Co. recently received a $10 million contract to build 47 target warheads of various configurations (decoys, multiple warheads, etc.) for both Atlas and Titan missiles to test the performance of our only antimissile missile.

Detection and destruction—the basic elements in an ICBM defense

Least complicated system in the Nike Zeus program is probably the missile itself. Solid-fuel powered, the vehicle is about 50 ft long, weighs 20,000 lb at lift off. It has three stages: Booster, sustainer, and jethead (third stage). Third-stage engine is used primarily for maneuverability, not for velocity increase.

Four advanced radar systems are incorporated in Zeus. Acquisition radar, capable of scanning millions of cubic miles of space, performs initial detection of incoming warheads. Target-track radar then takes over and provides extremely accurate data on tiny targets hundreds of miles away. Discrimination radar separates decoys from real warheads, and missile-track radar guides Zeus to the target.



Circle 14-1 on Page 19 for extra copy.

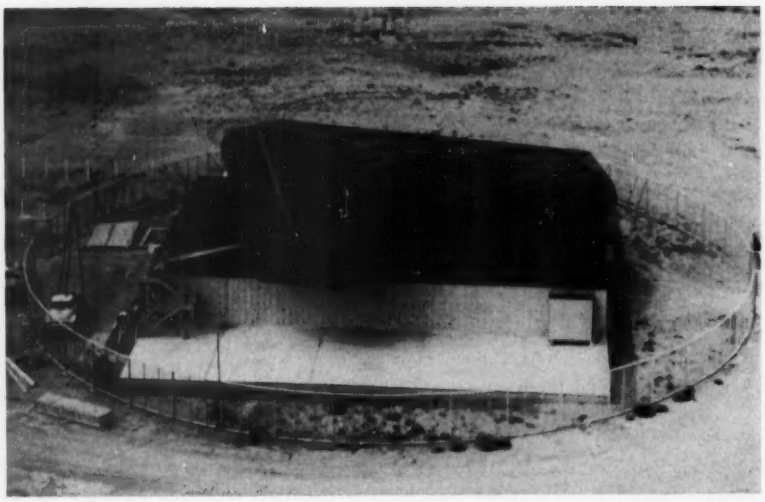
—are provided for in Nike Zeus by the most advanced radar systems in the world which guide the solid-fuel Zeus to the kill. Tremendous design and fabrication problems, mechanical as well as electronic, have been solved in the radar-development program. A typical electronic problem: The radar must be able to discriminate between armed warheads and decoys. A typical mechanical problem: Support bearing for the 100-ton acquisition radar receiver antenna is 30 ft in diameter, yet has an accuracy tolerance of 0.005 in.

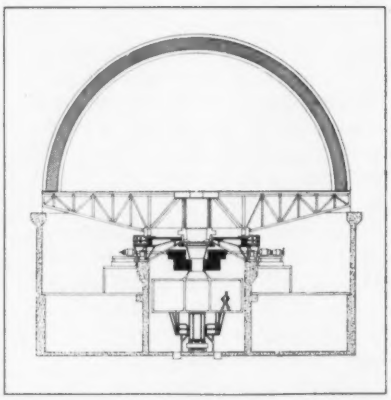
Design of computers for Zeus also strained the state of the art. Time element between acquisition of a target and intercept has been estimated at about 3 min. Within this time, the computer collects and processes information from four radar systems to define the target and its trajectory and launch and guide the antimissile missile to its kill. The computer must be able to provide track information on a large number of targets simultaneously and make the decision for single or salvo firings.

Zeus, itself, is relatively straightforward in design. Being a terminal defense weapon, it was built for speed rather than range (which is probably no more than 100 mi). Its booster engine, rated at 450,000 lb thrust, is the largest single-grain, solid-propellant engine in the world. Booster burning time is only 5 seconds—a sort of extended explosion—which gives the missile tremendous acceleration. Entire exterior surface of Zeus is covered with plastic ablative material to prevent its melting down in the atmosphere.

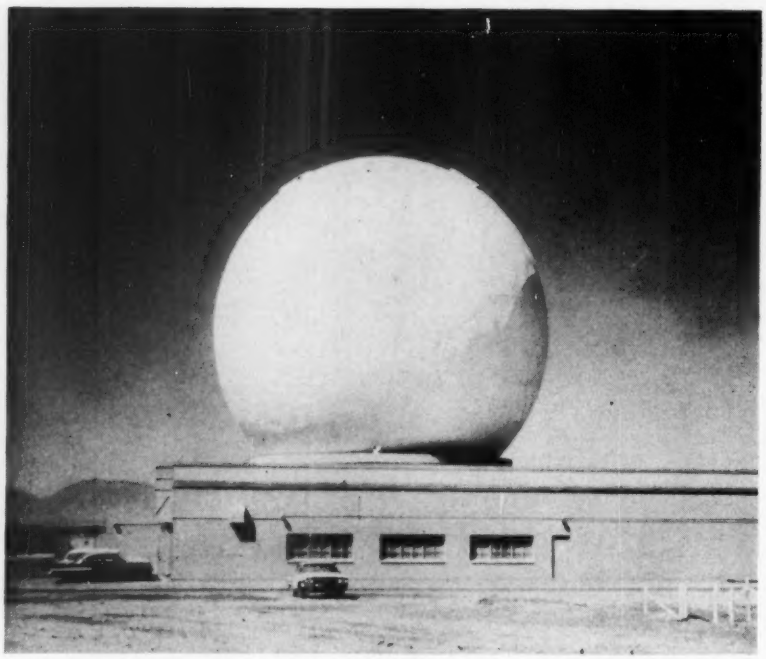
Armed with a nuclear warhead, Zeus would not have to make a precise intercept. Conservative guesses put the effective miss distance at one mile to immobilize an ICBM nuclear warhead.

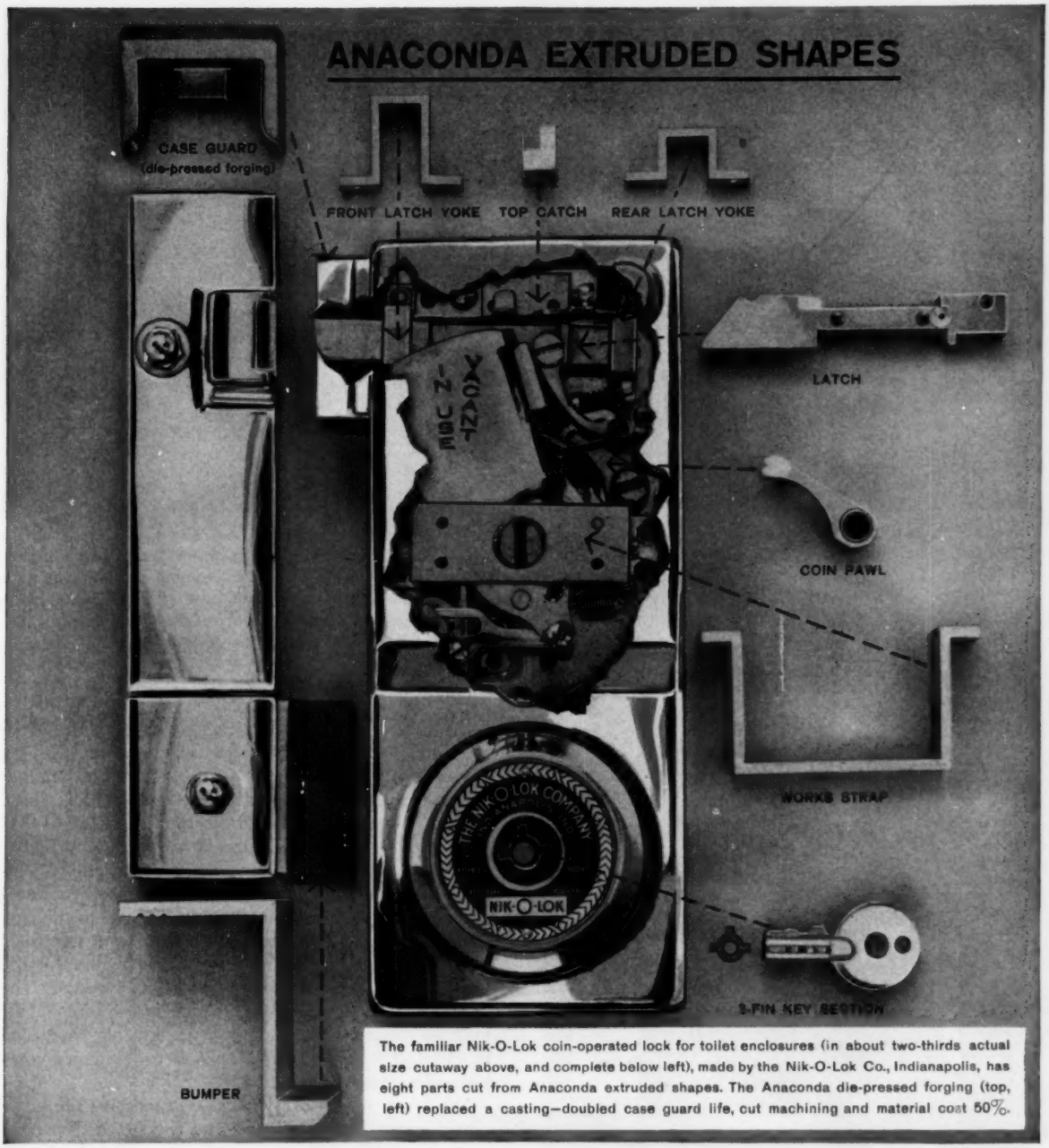
Prime contractor for Zeus is Western Electric Co.; major subcontractors include Douglas Aircraft Co. (complete missile and related equipment) and Bell Telephone Laboratories (system design). Goodyear Aircraft Corp. designed several of the largest radar components, including the acquisition transmitter and receiving antennas.





Extreme power output of Zeus acquisition radar dictated use of separate transmitting and receiving antennas. Triangular transmitting unit (above) consists of three 80-ft long arrays. Mounted atop a huge half-buried transmitter, it rotates 360 degrees in azimuth. Receiving antenna (right, below) is an 80-ft diameter solid hemisphere made of plastic foam impregnated with precisely aligned slivers of metal. It performs much like an optical lens, focusing the returned radar pulses on multiple receiver horns. Forty-two boxcar loads of plastic, fabricated into 18-in. cubes, were required for construction of the receiver hemisphere.





The familiar Nik-O-Lok coin-operated lock for toilet enclosures (in about two-thirds actual size cutaway above, and complete below left), made by the Nik-O-Lok Co., Indianapolis, has eight parts cut from Anaconda extruded shapes. The Anaconda die-pressed forging (top, left) replaced a casting—doubled case guard life, cut machining and material cost 50%.

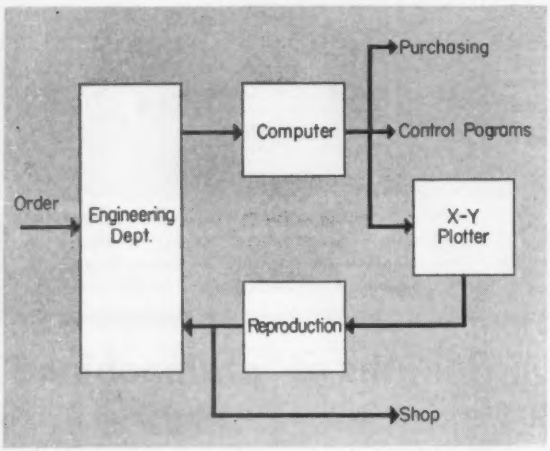
How parts sliced from long lengths of "premachined" brass shapes cut costs. It starts in design. You select cross sections which minimize subsequent machining—and scrap. The only limitation is that grooves, slots, etc., must parallel the axis of the extruded bar. The smooth surface of extruded shapes reduces many finishing operations. And high dimensional accuracy simplifies assembly. In addition, you get superior, long-wearing parts that improve the quality of your product, because of the strong, homogeneous wrought-metal structure of extruded shapes. For imaginative and practical help in adapting extruded shapes to the economical production of intricate parts, see your Anaconda representative. Or write: Anaconda American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

6143 ANACONDA®

Driven by a punched-card reader (background, left), the X-Y plotter automatically draws the switchgear panel laid out by the computer. The drawing is produced larger than the 8½ x 11-in. size in order to take advantage of all the print-out stations available. After the plotter has finished its work, the drawing goes to the reproduction dept. where it is photographed and reduced to the proper size (right). Conventional margins, title blocks, column headings, etc. are added by placing a transparent overlay containing this information over the drawing prior to photographing it.

Automatic Draftsman Thrives on Routine

Card-Controlled X-Y Plotter Streamlines Switchgear Layout



When the shop order is received, the engineers organize design requirements in terms of system parameters, assembly information, and unit description. This data, on punched cards, becomes the input to the computer, which selects components and determines how they will be arranged. Computer output, on punched cards, is routed to the purchasing and ordering dept., to inventory-control, and to the plotter. After the plotter prepares the drawings and the reproduction dept. reduces them to the proper size, prints go back to the engineers who add new or unprogrammed information. After this final step, the drawings go to the shop.

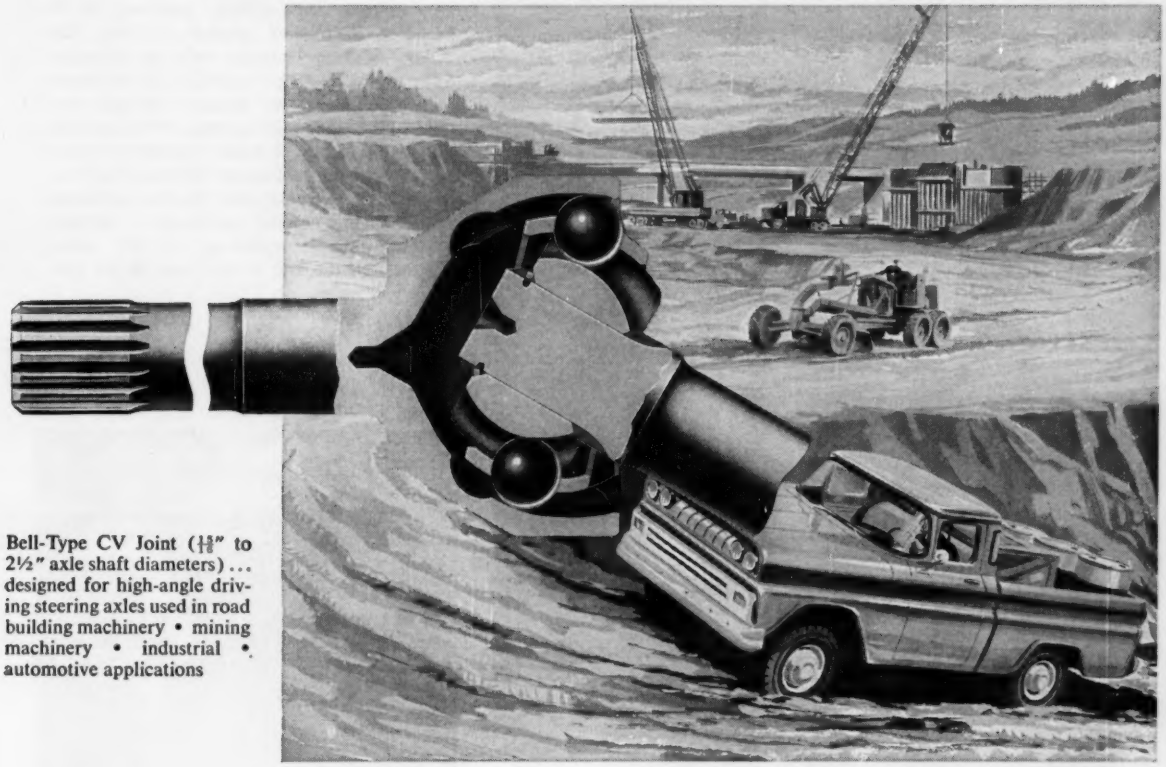
EAST PITTSBURGH, PA.—Drafting assignments are given to a computer at the Assembled Switchgear and Devices Dept., Westinghouse Electric Corp., and the computer instructs an X-Y plotter on how to make the drawings. Designed to free draftsmen from routine tasks, the system determines the optimum arrangement of components on a panel and draws up the answer.

The computer applies logical analysis to a considerable degree in designing equipment tailored to the customer's needs. Its job is to locate parts to suit the situation. Since the parts are invariably dictated by the application, there is little creative effort involved. The ultimate collection and arrangement of components may be unique, but it is always predictable, according to Herman B. Wortman, Westinghouse advisory engineer who set up the program.

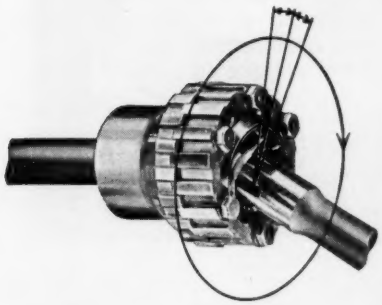
When an order for switchgear comes in, the engineering dept. breaks it down into fundamental parameters of voltage and current rating, etc. Switchgear design basically involves an assembly of stocked components, and parts used are selected according to application and rating requirements. Thus, certain parts are unique to 1200-amp circuits, others are used only in 5-kv assemblies.

First, the engineers check off the important parameters for the particular application. Then, the check list (translated on punched cards into computer language) and information on the desired output are fed into the computer. From here on, the panel design is up to the computer. It searches its memory (a catalog of all the components that are available) for parts to be used and goes through the logic process to determine the correct positioning. Computer output becomes the input to the plotter which produces the drawings.

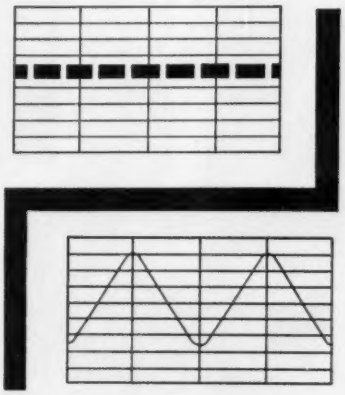
CON-VEL (RZEPPA) CV Universal Joints Give Longer Life, Higher Torque Capacity!

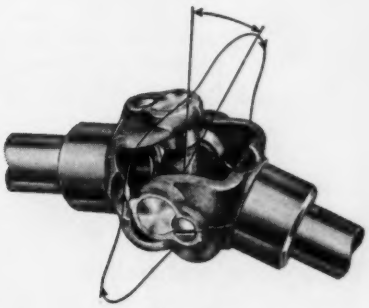


Bell-Type CV Joint (1⅛" to 2½" axle shaft diameters) . . . designed for high-angle driving steering axles used in road building machinery • mining machinery • industrial • automotive applications



Disc-Type CV Joint (from 2⅛" to 16¼" swing diameter) . . . designed for all types of industrial drive applications. Rzeppa Joints always transmit torque smoothly, even at unbalanced angles. Note constant velocity of 100% for Rzeppa Joint.





During rotation at a given angle, pin or slipper-type joints speed up, slow down twice during one revolution, as shown by the solid line in the graph.

DANA Con-vel

CON-VEL DIVISION

DANA CORPORATION

3901 Christopher
Detroit 11, Michigan

WRITE

for your free copy of this new engineering data folder on the complete line of Rzeppa constant velocity joints.

Circle 215 on Page 19

Antenna with a foam reflector

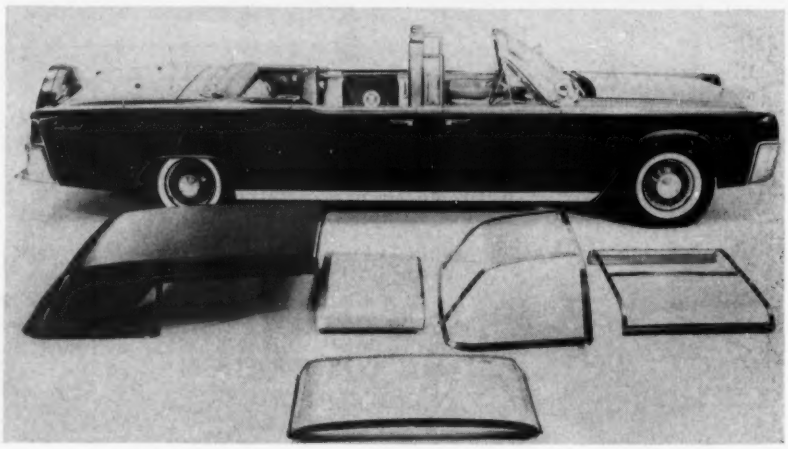
is expected to find use in satellite communication and radio and radar astronomy. The reflector is styrofoam joined with urethane foamed-in-place seams. Placed on a special, computer-controlled milling machine, it is shaped to the desired parabolic contour. The 12 legs are long hydraulic cylinders. Changes in length of the legs—controlled by a servomechanism—move the reflector through any angle of azimuth and elevation. The antenna was developed by Sylvania Electric Products Inc., a subsidiary of General Telephone & Electronics Corp. Sylvania says it is less expensive, stronger, lighter weight, and easier to fabricate than conventional equipment. A 60-ft metal reflector weighs about 15 tons; one of the new design will weigh only 3 tons.

Battery-powered lawnmower

cuts for 1½ hours on one charge, and the motor can be recharged overnight. Six 12-in. blades make about 70 cuts every 36 in. The mower's transmission is controlled by a single lever; disengaging the drive permits free movement backwards and forwards. Weight of the machine is 104 lb. It is made by H. C. Webb & Co. Ltd., Birmingham, England.

Mix-or-match roof sections

for the new Presidential limousine offer a choice of a metal top; an all-plastic covering; a fabric top; no top at all; or a variety of combinations for rear, middle, and front compartments. The car is a Lincoln Continental convertible which was cut in half, reinforced, and lengthened 41 in. The body was reinforced, drive-shaft components were redesigned and reinforced, and many heavy-duty chassis components were used. Powerplant is a standard Continental 430-cu in. engine. Over 21 ft long, the car has a wheelbase of 156 in., weighs 7822 lb. The better to see the President, its back seat raises 10½ in.

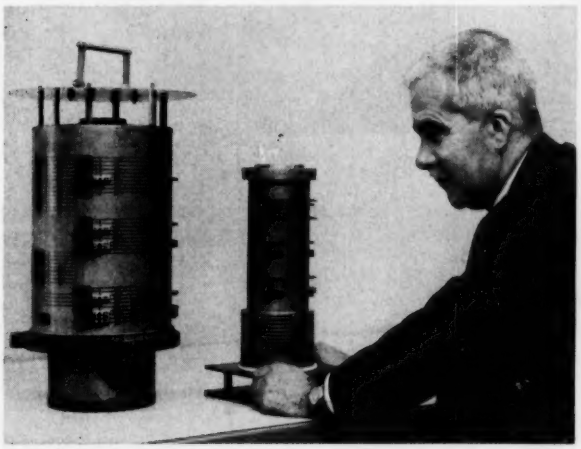


Airlift for rockets

is proposed to save travel time from builder to launch area. Piggybacking the Saturn second stage (S-IV) from Douglas Aircraft's Sacramento, Calif. field station to Cape Canaveral would take about 10 hours. Shipping it via the Panama Canal requires three weeks. Proposed rocket transport is the Douglas C-133 cargo carrier, which would require minor modifications to the tail section for added directional stability. The rocket itself would have lightweight fairings attached to the front and rear to minimize drag.

ENGINEERING NEWS

PICTURE REPORT

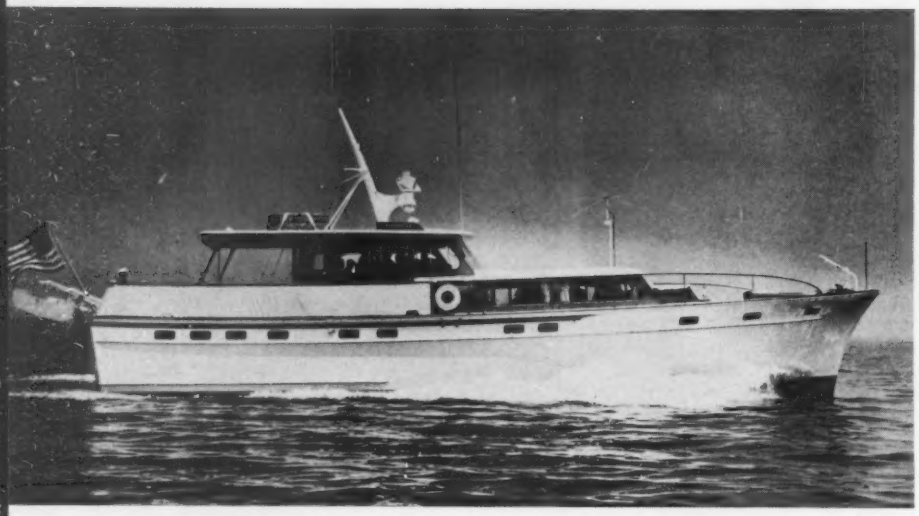


Compact memory drum

stores 286,000 items of information in one-seventh the area of its predecessor (left). Packing density was increased from 80 to 160 items per inch. Developed by Hughes Aircraft Co. for use in military mobile electronic defense systems, the new drum is made of stainless steel—which cuts cost by eliminating the copper and nickel cobalt plating required on the aluminum model. It also claims greater reliability because of higher strength-to-weight ratio, corrosion resistance, high stability, and less expansion under heat than aluminum.

Standard equipment

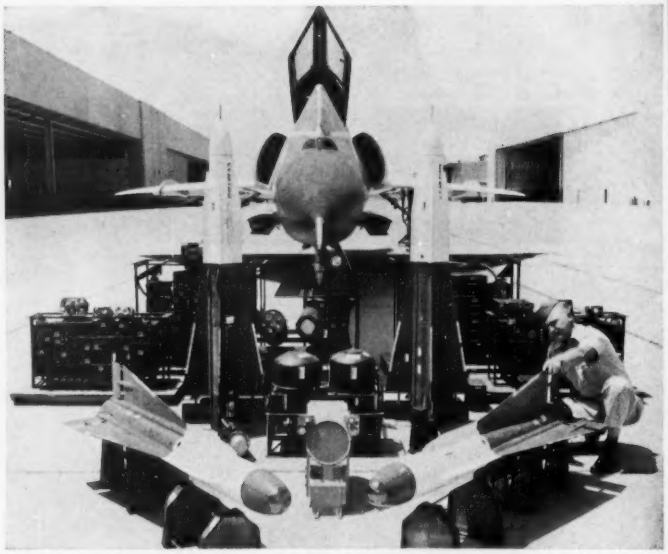
on all production models, seat-belt anchors are built as integral parts of the body shell on British Motor Corp. cars. Points of attachment for the diagonal-sash and lap belts are on the door pillar, the drive shaft tunnel, and the door sill. Mounting brackets are secured through the car body to reinforcing plates of ¼-in. tensile steel. B.M.C. is the first big British car manufacturer to offer built-in seat-belt fittings.



The largest hull

ever molded of fiber-glass reinforced plastic was made for the 67-ft Maimelee. It weighs 14,500 lb and was molded in one piece by Halmatic Ltd., Portsmouth, England. The Maimelee, designed by John G. Alden & Co., Boston naval architects, is the first of a series of 67-footers.

PICTURE REPORT

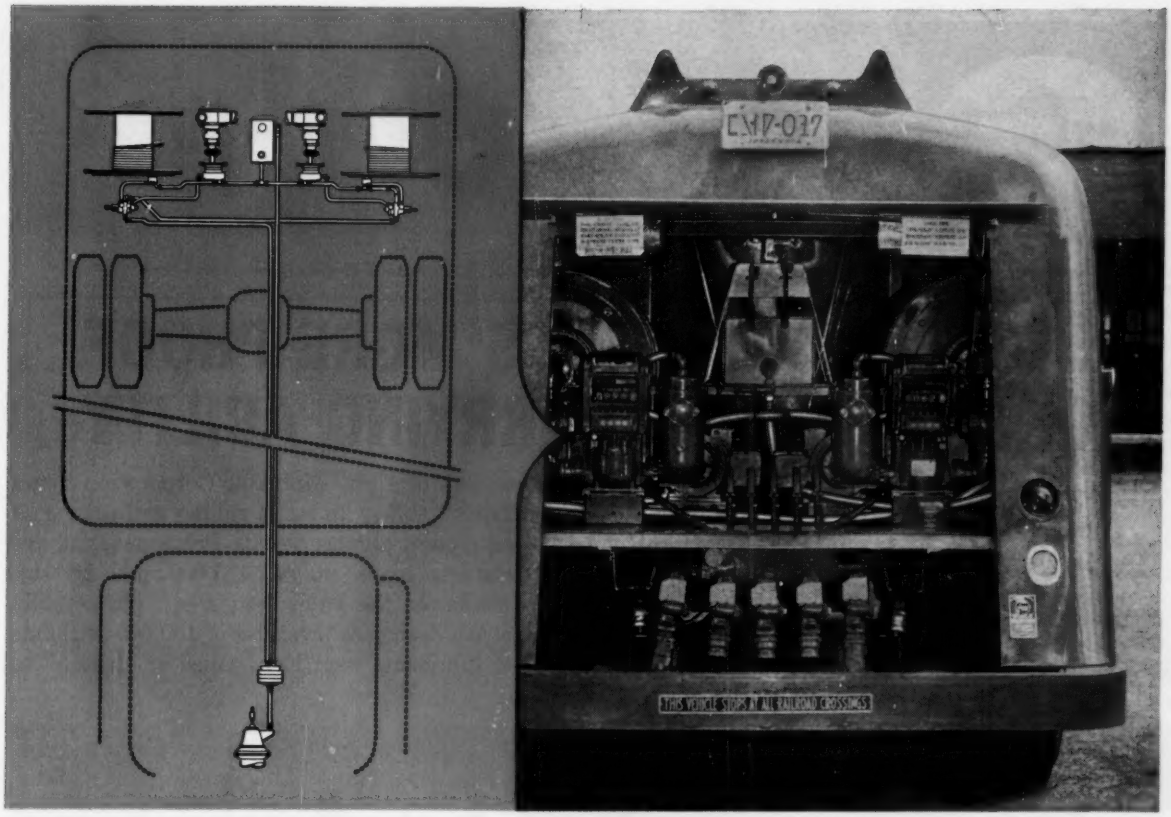


Infrared for interceptors

will allow them to locate targets at low altitudes without being detected themselves. Three supersonic jets—Convair's F-106A (shown) and F-102A and McDonnell's F-101B—are being "upgraded" with the infrared search and track equipment. Each plane will receive one or more further modifications (redesigned radar antenna, counter-counter-measure capabilities, or a parametric amplifier which reduces radar interference) to increase its effectiveness against manned bombers. Air Force and Hughes Aircraft Co. are carrying out the jets' modernization program.

Putting on weightlessness

introduces mealtime problems which are solved in the space kitchen designed for the Air Force by Whirlpool Corp. Getting the food out of cans and into a spaceman is done by removing caps at both ends of the can and installing a nipple at one end and a ratchet-type force feeding device at the other. Beverages, packaged in plastic tubes, are consumed by squeezing the contents into the diner's mouth. After he has warmed his meat and vegetables in the oven (left), the astronaut straps himself onto a stool and eats off the vertical tray, to which cans, beverage tubes, and bread and butter are fastened (right). Food for a three-man crew on a 14-day mission can be stored and prepared in the 10 by 7½-ft kitchen. It contains freezer, refrigerator, oven, hot and cold water, and waste disposal systems.



Ardmore Products relies on Gates Hose for long, dependable service of hydraulic systems

Gates Hydraulic Hose is standard equipment on hydraulic systems made by Ardmore Products, Northbrook, Illinois. These systems are used on tank trucks for pumping petroleum products and for power drives for hose reels.

The Ardmore Hydraulic Drive System is considered explosion-proof . . . is easy to install . . . and is virtually maintenance-free. All connections are made with Gates Hydraulic Hose.

Mr. Edward J. Doyle, Jr., Ardmore General Manager, says, "We use Gates hose to assure the dependability and quality of our product. Furthermore, Gates offers the best in service and in technical assistance."

Ask for Gates technical aid in designing hydraulic systems.

The Gates Fieldman located near you is a fully-qualified hydraulic hose expert. He can give you valuable assistance in designing hydraulic hose systems. Ask him for Gates Hydraulic Hose Assemblies booklet, IH43.

GATES HIGH PRESSURE HYDRAULIC HOSE (54MB)
Meets or exceeds SAE specifications. Withstands shock loads and heavy pulsating pressures. Reinforcing braid is flexible, high-tensile wire. Leakproof coupling is permanently attached.
Gates Hydraulic Hose is quickly available anywhere from nearby stocks.
Building the future on 50 years of progress
Gates

The Gates Rubber Company, Denver, Colorado

BP 32

Gates Hydraulic Hose

Circle 216 on Page 19

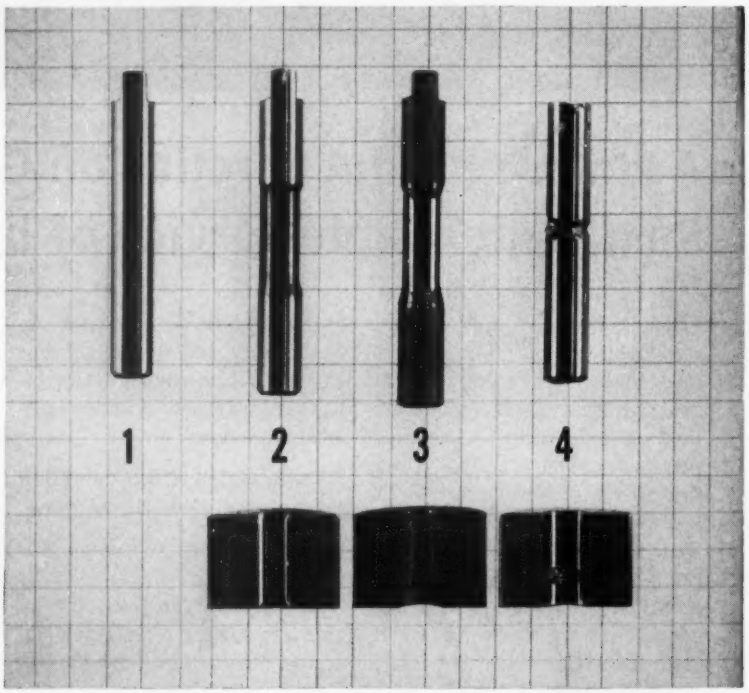
CLIMAX MOLYBDENUM

Molysulfide® News Digest

CLIMAX MOLYBDENUM COMPANY, a division of American Metal Climax, Inc., 1270 Avenue of the Americas, New York 20, N.Y.

RECENT TEST SHOWS MORE PROOF OF MoS_2's LOAD-CARRYING ABILITY

From the German laboratory of Alpha Molykote Corporation comes new proof of Molysulfide's® ability to resist galling and seizing at pressures beyond the yield point of most metals. Previous tests have shown that MoS_2 sustains loads up to 475,000 psi. In this Almen Wieland test, similar to the Falex test, a ¼" pin actually extruded *without any surface damage* at pressures of 100,000 psi, while similar pins using other lubricants were torn, galled or "frozen" to the point of breakage.



The photo above shows mild steel pins used in Almen Wieland test. No. 1 is unused Control Pin. No. 2 (lubricated with mineral oil and MoS_2) and No. 3 (with MoS_2 bonded coating) were elongated and extruded without weight loss. No. 4 shows typical failure with conventional lubricant. Note that the key sheared off and that pin and block were galled and seized. Surveys of many laboratories indicate that the extrusion phenomenon exhibited by No. 2 and No. 3 pins has never been produced with any other conventional lubricant.

As a result of Molysulfide's unique pressure-sustaining ability, MoS_2 is widely used as a "break-in" lubricant which prevents abrasion and seizing, permits shorter "break-in" runs, and prevents bearing damage when boundary lubrication occurs.

When writing, refer to CL-107

New Teflon-MoS_2 Bearing Component Withstands Temperatures Up To 575°F

A new precision ball bearing, which operates at temperatures up to 575°F and needs no conventional lubrication, is now coming off the lines at the Barden Corporation's plant in Danbury, Conn. Trade-named BAR-TEMP, the new bearing utilizes a ball retainer of reinforced Teflon compounded with "Moly" lubricant. Resistance to deformation is much higher than that of pure Teflon*. Also, the material serves as a *dry lubricant*. As the bearing rotates, microscopic amounts of Molysulfide rub off and are deposited on the raceways. Result: long bearing life at temperatures where conventional lubricants fail.

Successful applications include synchros, fans, motors, blowers, barometic pressure switches, tachometer generators, and other devices operating from 1,000 to 24,000 rpm, at temperatures ranging from –100°F to 575°F.

*T.M. E. I. du Pont de Nemours & Co., Inc.

When writing, refer to CL-105

"Moly" GIVES WIRE ROPE 45% MORE BENDING LIFE

That's the forthright verdict of one of the leading wire rope manufacturers, which recently tested its MoS_2-lubricated wire rope against four other leading brands. Fatigue tests and field tests demonstrated the rope's ability to outlast other premium wire ropes in service.

Used as an ingredient in wire drawing compound, Molysulfide creates a micro-shield around each wire. This smooths out minute surface imperfections and prevents the wires from grinding together as the rope flexes. Result: reduction of internal friction —better resistance to fatigue—far longer rope life.

When writing, refer to CL-106

High-Frequency Ignition Betters Two-Cycle Performance

Cure for Hard Starts Immune to Dirt, Water

BUCKINGHAM, ENGLAND — Performance of two-cycle engines is improved significantly by a new high-frequency ignition system designed specifically for two-stroke operation. One of the advantages claimed for the system: It reduces hard starting due to erratic fuel/oil mixture, one of the few remaining trouble areas in two-cycle performance. Known as the Magister system, the ignition was developed by Wipac Group Sales Ltd., Buckingham, England.

Although condenser discharge, which the ignition uses, is not new, previous systems have usually proved to be too expensive, and most have required relatively costly surface-discharge type spark plugs.

Feed Coil

Basically, the Magister system differs from conventional magneto ignition in that the high-tension ignition coil is replaced by a feed coil. Ac power, induced from this in the conventional manner, is rectified to dc which, in turn, charges a condenser. The charge is retained by the condenser until the contact breaker closes. At closure, the stored current is discharged through the ignition coil, which again uses primary and secondary windings, producing a high voltage for the spark plug.

Producing the spark during the closing of the contact breaker is said to have distinct advantages. When the spark is produced at the time of point opening, the arc formed by the current exists over an extended period. When the contacts are closed at time of spark, the condenser discharge rate is of a much higher order; reduced arcing gives an increase in point life.

With the conventional magneto, timing is of utmost importance. With the Magister discharge system, it is not so critical—the condenser holds its charge until the contact breaker closes. While a recommended contact clearance is given, variations do not affect the magneto output.

Experiments with a wide variety of engines show that the initial rate of burning achieved with the Magister unit makes it necessary to retard the ignition by 3 to 4 degrees, indicating that the firing of the mixture in the combustion chamber is initially of a higher flame rate than with the conventional system. This retarding effect still provides optimum power from the engine.

Other tests designed to subject the engine to conditions of extreme misuse included throwing dust and oil between the contact-breaker points, pouring water over the spark plug, smearing the plug in sump oil and dirt, and inducing oil at the air intake. The engine started and continued firing in all tests.

Four-Cycle Advantages

While the advantages of the system are not so pronounced for four-stroke engines, tests have shown that it is possible to use varying grades of fuel on a standard four-stroke engine with no special adjustment to the carburetor or to ignition timing. Changes of fuel, (e.g., gasoline, diesel, paraffin, etc.) can be made after only a very short warm-up with no power loss.

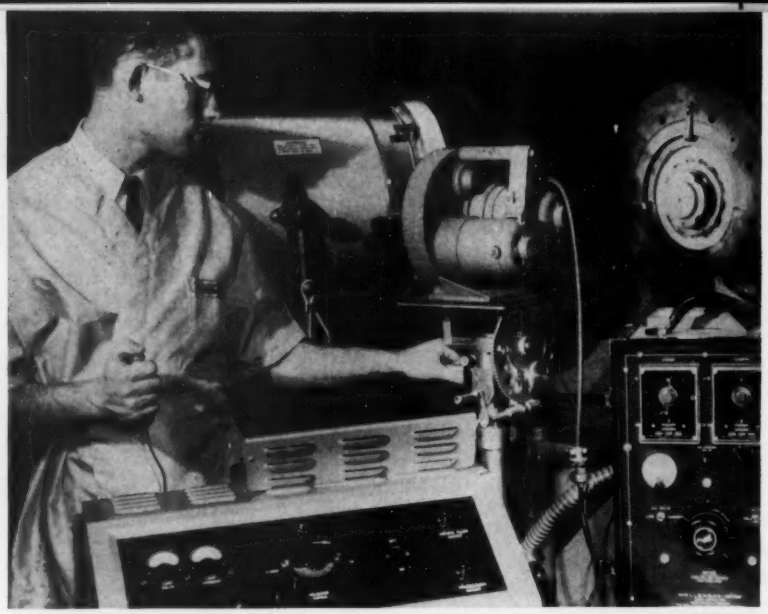
Jet Assist for the Foot Soldier

BUFFALO, N. Y.—The minimum flying machine developed by Bell Aerosystems Co. has completed its 30th successful flight with a perfect record. The unique man-rocket consists of a twin-jet propulsion system mounted on a figerglass corset which has been moulded to fit the back and hips of the operator. The operator slips his arms through padded lift rings, attached to the corset, and secures the unit with two quick-release safety belts passing around his abdomen.

Metal control tubes, attached to the lift rings, extend forward on each side of the operator. A control stick on one tube permits the pilot to change his flight direction; a motorcycle-type hand throttle mounted on the other allows him to regulate thrust level for control of his rate of climb and descent. The device has proved so stable in flight that pitch and roll are easily controlled by movements of the operator's body.

Fully throttleable, the Bell propusion system uses hydrogen peroxide for fuel. The H_2O_2 is forced under pressure into a gas generator where it contacts a catalyst and decomposes into steam. Escape of the steam through two rocket nozzles provides thrust. Main thrust is directed toward the ground; jet deflectors provide the necessary thrust for yaw control. Position of the rocket nozzles and the low temperature of the steam exhaust eliminate the need for special protective garments to shield the operator.

Human airframe for Bell's one man rocket is test engineer Harold M. Graham. During free-flight tests, Graham has covered ground distances of 300 ft and has soared to the top of 30-ft high hills.



By beaming polarized light at rolling-element bearings and studying the colored fringe patterns that are reflected, SKF researchers are developing guide lines for better cage design. They are able to detect flaws in new designs, analyze how well current production gages are working, and provide more suitable designs for specific applications. In addition to cage stresses, tangential forces between rollers and races can also be determined accurately.

Camera Spots Stresses in Roller-Bearing Cages

PHILADELPHIA — When rotating under a load, rolling elements of a bearing set up stresses in the cage. Until recently, designers couldn't effectively allow for the stresses because there was no sure way to measure the forces involved. Now, however, a new photoelastic method solves the problem.

The new method is the first to be successful in measuring forces on bearing separators, according to engineers at SKF Industries Inc. who developed the technique. It is expected to provide data for increased cage strength and life, which in turn will allow greater bearing reliability and longevity. SKF researchers are studying stress distribution under given loads and how the distribution changes when cage shape is modified.

The measuring technique requires coating the surface (or side) of the cage with a layer of birefringent plastic material. Held in place by a reflective adhesive, the plastic is illuminated by polarized light, which reflects back from the adhesive through a polaroid filter. Behind the filter, highly colored fringes are revealed that tip off the magnitudes of stress present in the cage.

The photoelastic fringes are recorded by a high speed camera (4000 pictures per sec) that can include the entire bearing cage in its field of view. Each picture records stress at a particular instant.

Rocket Propellants Lubricate Bearings

Cages Are Critical in Cold, Caustic Environment

PHILADELPHIA — Rocket propellants can double as lubricants for rocket-engine turbopumps, delegates were told at the recent meeting of the American Society of Lubrication Engineers. According to M. F. Butner and J. C. Rosenberg, of North American Aviation's Rocketdyne Div., initial testing has shown that bearings can operate in the propellants if suitable cage material is used.

The lightweight turbopumps are designed to operate at high speeds and high shaft-bearing loadings to deliver large quantities of fuel and oxidizer. Conventional lubricants will work, but they introduce two problems:

• Cryogenic propellants such as liquid oxygen (−320 F) and liquid hydrogen (−423 F) freeze the lubricants. Heaters are mandatory, but they increase weight, complexity, and power requirements.

• Most rocket propellants are not compatible with the lubricants, and mixtures of the two can be explosive. Complicated sealing arrangements are necessary to prevent contact of the two fluids.

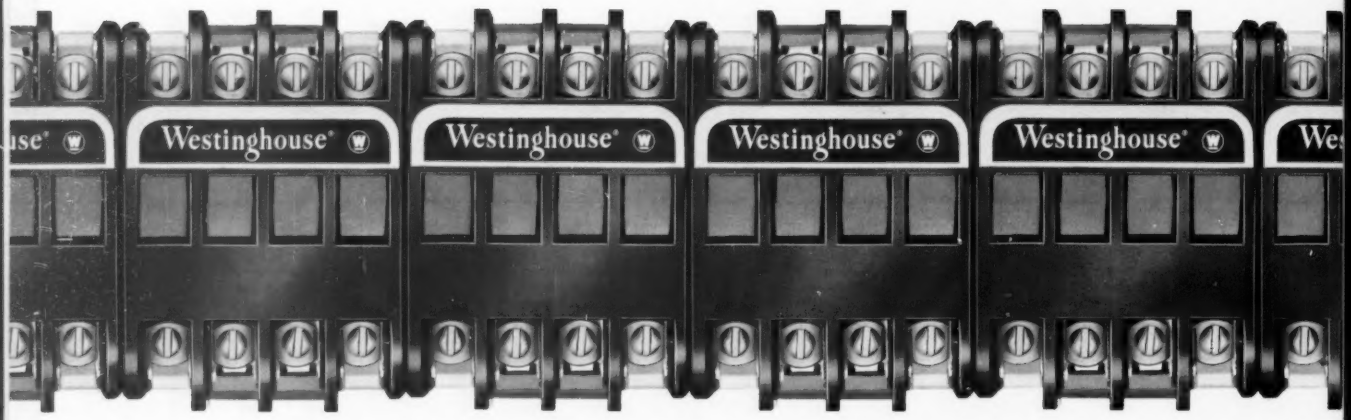
Material compatibility is the major problem when operating antifriction bearings in liquid hydrogen, liquid oxygen, and nitrogen tetroxide. Soaking tests and subsequent operation proved 440-C steel best for use in these fuels. Corrosion-resistant bearing materials are required with the cryogenic fuels to avoid rust caused by post-run condensation on chilled surfaces. And if moisture content of nitrogen tetroxide exceeds 0.1 per cent, nitric acid forms that is strong enough to badly corrode conventional bearings.

In all cases, testing indicated deterioration of sliding surfaces of the cage is a more severe problem than that of rolling contact between balls and races. Data showed that a nonmetallic cage surface must be used. Glass-supported polytetrafluoroethylene and glass-filled PFTE were the best cage materials tested, although other plastics may also be suitable. The glass-supported PFTE is probably the better of the two because of its greater strength.

Tests in RP-1 indicate that this fuel is adequate as a lubricant for heavily loaded bearings. In short-life high-load operation, ball bearings lubricated with RP-1 performed like those that were oil lubricated. Since the fuel is a petroleum-type fluid, it does not present a serious material compatibility problem. However, use of a jet system to deliver the lubricant is desirable because submerged operation causes churning and heating of the high-viscosity fuel.

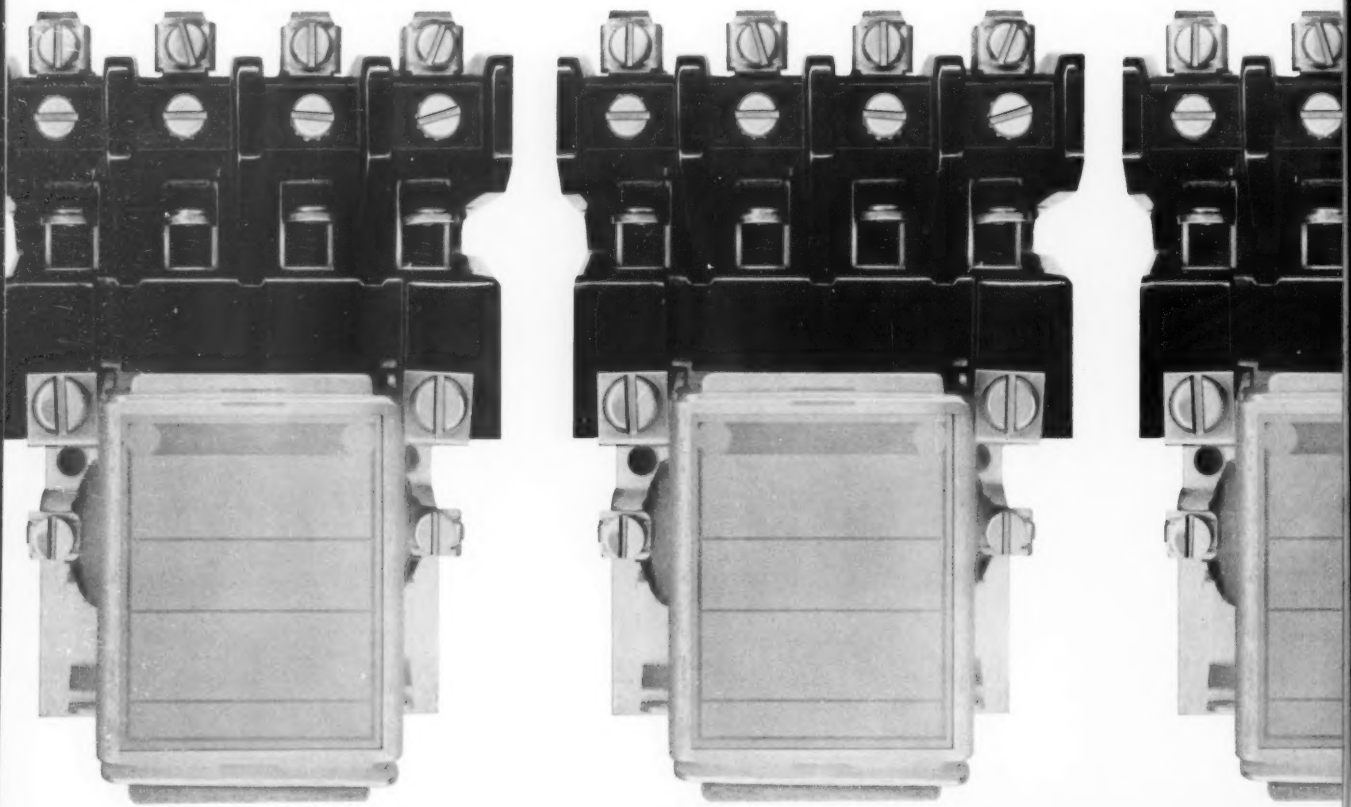
Circle 218 on Page 19→

New Westinghouse BF relay shrinks machine control relay panel space 33% to 78%



See for yourself how many new Westinghouse BF relays

ALL PHOTOS ACTUAL SIZE



General characteristics of the Westinghouse BF relay

Dimensions

Without base plate: 1 11/16" x 2 3/8"
With base plate: 1 11/16" x 3 1/8"

Operating time

Pickup: 12.5 to 18.0 milliseconds
Dropout: 6.25 to 12.5 milliseconds

Relay can be operated manually to test circuits.

4 and 8 pole frames in any combination or normally open and normally closed contacts with a maximum of 4 normally closed.

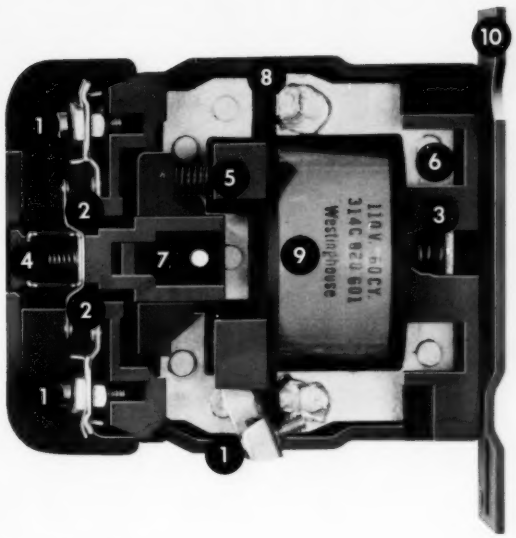
Contact rating—6 amps. 300 volts AC. 60 amperes inrush.

Relay can be mounted in any position on a vertical surface without changing operational characteristics.

The Westinghouse BF relay provides these features

- up to 78% less mounting space required
- front accessible
- can be butted without extra space for wiring
- quick coil and contact changes when needed
- low operating temperature
- lower installed cost
- long service life
- magnet and armature have specially hardened pole faces
- shorter operating stroke
- lightweight operating parts
- silver alloy contacts have built-in wiping action for prolonged circuit continuity

How the new Westinghouse design assures reliability and durability



EASILY WIRED

1. All connections are wired from the front with pressure clamp terminals.

OUTSTANDING CIRCUIT CONTINUITY

2. Proper contact wipe is built-in for long life of the silver alloy contacts and for positive circuit continuity.
3. Contact bounce is minimized by unique magnet suspension that eliminates shock and jar.
4. Automatic, positive alignment of crossarm insures simultaneous contact of all poles.

POSITIVE OPERATION

5. Stainless steel kickout springs permit any mounting position on a vertical surface — independent of gravity.

LONG MECHANICAL LIFE

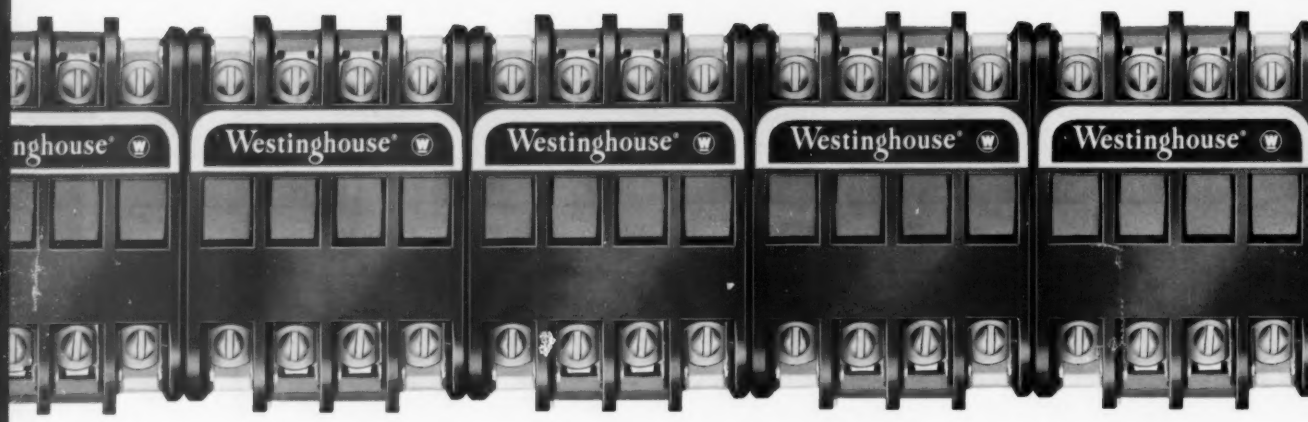
6. In addition to preventing contact bounce, the magnet suspension cushions the contact between armature and magnet, protecting entire unit from shock.
7. Low mass and short stroke, possible only with a small relay, save wear on every moving part.
8. Pole faces are surface hardened to maintain desired air gap.

MINIMUM POWER LOSS

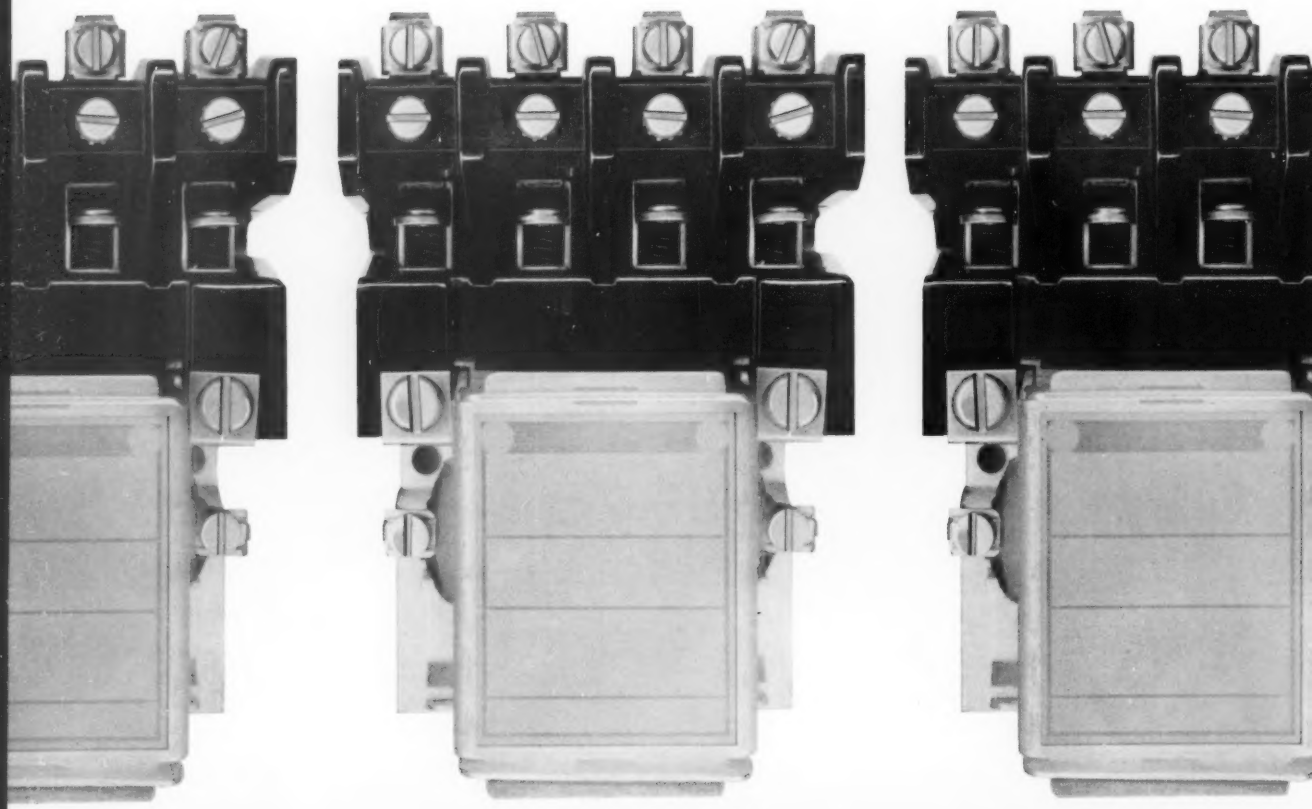
9. Closed gap coil loss is only 3 watts for low coil operating temperature. Open coil burden 70 volt amps; closed, 11 volt amps.

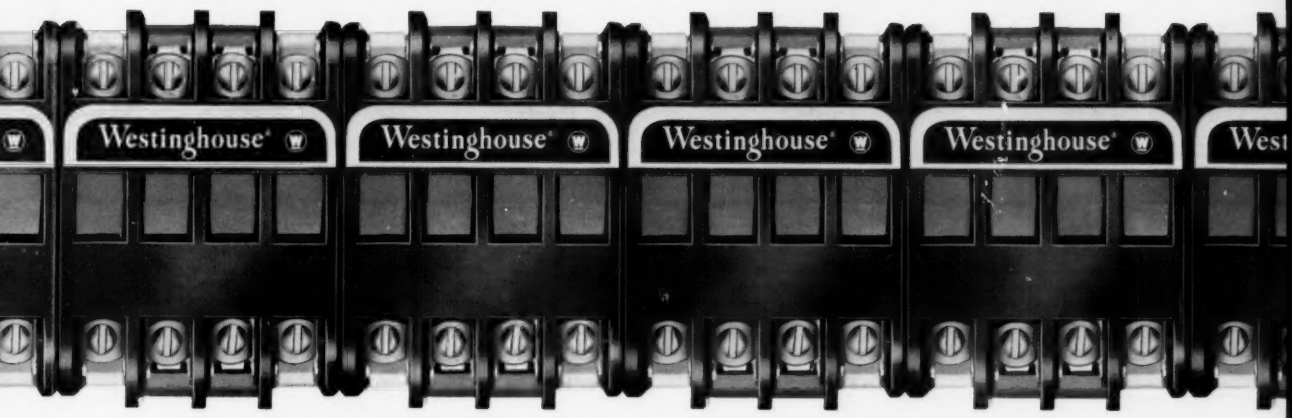
EASE OF MOUNTING

10. Steel base has keyhole slots for rapid installation, extends only into wiring area to avoid space waste, and may be removed if desired.



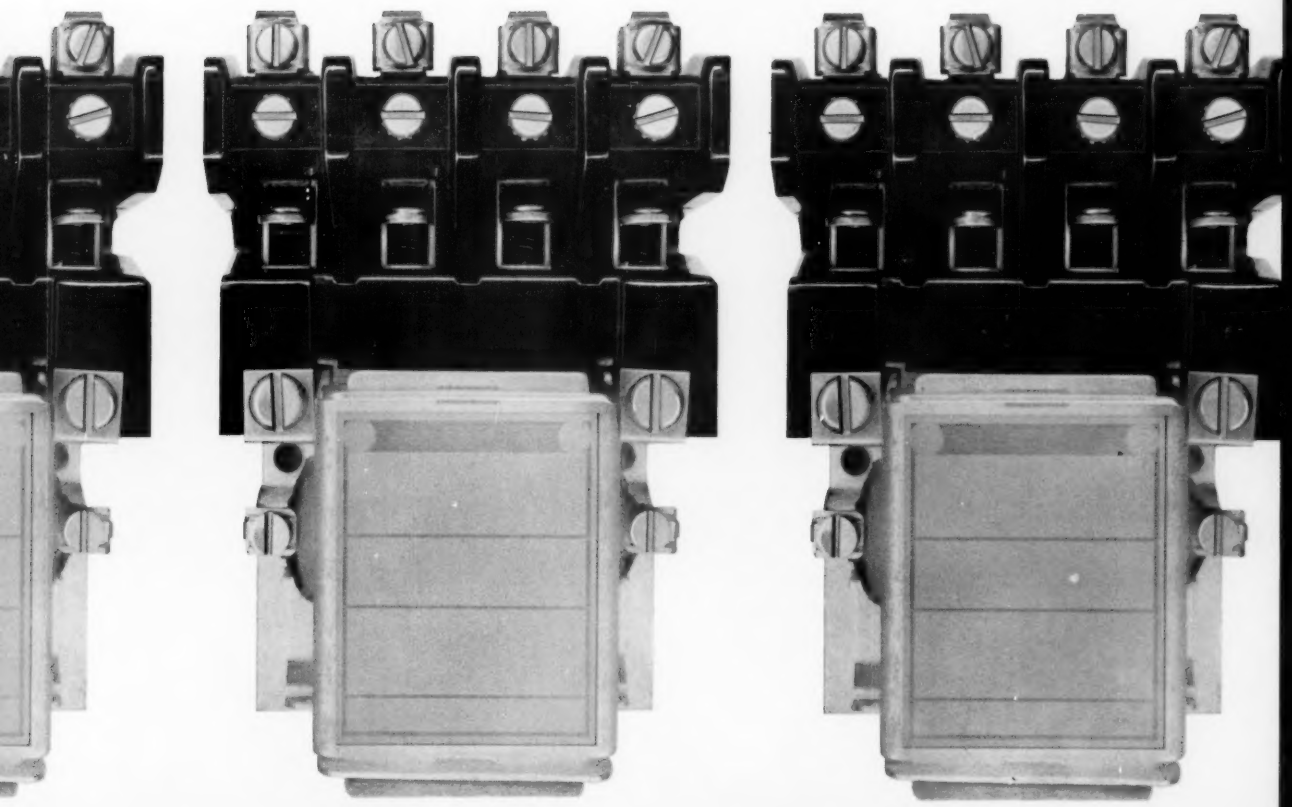
can fit in the same space as 7 conventional relays—this i





s is how control panels can be reduced as much as 78%

You can be sure . . . if it's Westinghouse



General characteristics of the Westinghouse BF relay

Dimensions

Without base plate: $1\frac{11}{16}$" x $2\frac{3}{8}$"
With base plate: $1\frac{11}{16}$" x $3\frac{1}{8}$"

Operating time

Pickup: 12.5 to 18.0 milliseconds
Dropout: 6.25 to 12.5 milliseconds

Relay can be operated manually to test circuits.

4 and 8 pole frames in any combination or normally open and normally closed contacts with a maximum of 4 normally closed.

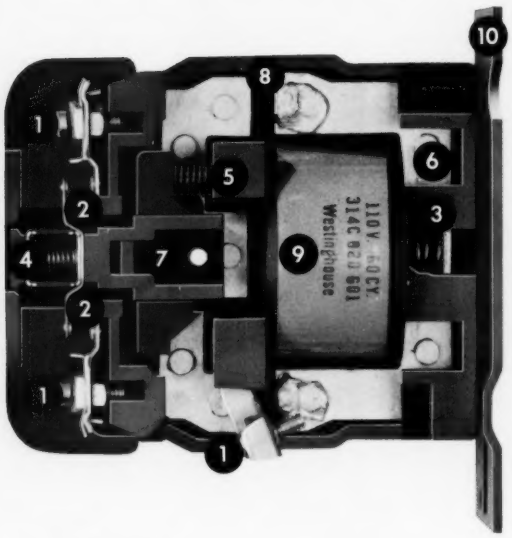
Contact rating—6 amps. 300 volts AC. 60 amperes inrush.

Relay can be mounted in any position on a vertical surface without changing operational characteristics.

The Westinghouse BF relay provides these features

- up to 78% less mounting space required
- front accessible
- can be butted without extra space for wiring
- quick coil and contact changes when needed
- low operating temperature
- lower installed cost
- long service life
- magnet and armature have specially hardened pole faces
- shorter operating stroke
- lightweight operating parts
- silver alloy contacts have built-in wiping action for prolonged circuit continuity

How the new Westinghouse design assures reliability and durability



EASILY WIRED

1. All connections are wired from the front with pressure clamp terminals.

OUTSTANDING CIRCUIT CONTINUITY

2. Proper contact wipe is built-in for long life of the silver alloy contacts and for positive circuit continuity.
3. Contact bounce is minimized by unique magnet suspension that eliminates shock and jar.
4. Automatic, positive alignment of crossarm insures simultaneous contact of all poles.

POSITIVE OPERATION

5. Stainless steel kickout springs permit any mounting position on a vertical surface — independent of gravity.

LONG MECHANICAL LIFE

6. In addition to preventing contact bounce, the magnet suspension cushions the contact between armature and magnet, protecting entire unit from shock.
7. Low mass and short stroke, possible only with a small relay, save wear on every moving part.
8. Pole faces are surface hardened to maintain desired air gap.

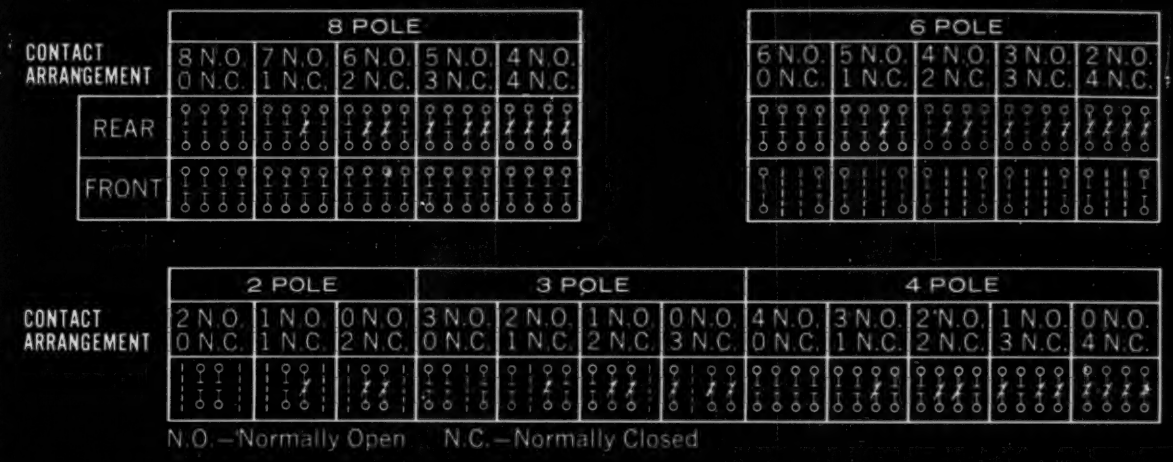
MINIMUM POWER LOSS

9. Closed gap coil loss is only 3 watts for low coil operating temperature. Open coil burden 70 volt amps; closed, 11 volt amps.

EASE OF MOUNTING

10. Steel base has keyhole slots for rapid installation, extends only into wiring area to avoid space waste, and may be removed if desired.

BF relay contact information



N.O.—Normally Open N.C.—Normally Closed

Westinghouse engineers have helped solve the design problem caused by the enlarged control panels needed to operate highly complex automated machine tools. The new Westinghouse BF Control Relay . . . although compact in size . . . has a rated full load current of 6 amperes at 300 volts AC. In new or modernized facilities, it *assures more productive capacity per square foot from every automated machine tool.*

Type BF—60 cycles

number of poles	contacts		open type catalog number
	normally open	normally closed	
2	2	0	BF20A
	1	1	BF11A
	0	2	BF02A
3	3	0	BF30A
	2	1	BF21A
	1	2	BF12A
	0	3	BF03A
4	4	0	BF40A
	3	1	BF31A
	2	2	BF22A
	1	3	BF13A
	0	4	BF04A
6	6	0	BF60A
	5	1	BF51A
	4	2	BF42A
	3	3	BF33A
	2	4	BF24A
8	8	0	BF80A
	7	1	BF71A
	6	2	BF62A
	5	3	BF53A
	4	4	BF44A

Ordering information

BF Relays are available direct through your nearest Westinghouse representative. When ordering be sure to specify the total number of poles desired, including the number of poles open and the number closed. Also specify coil control voltage and cycles. The chart at the left shows some of the most widely used relays with 110-volt, 60-cycle control voltage. Consult your Westinghouse representative about other BF Relays which are available. Or write Westinghouse Standard Control Division, Beaver, Pa.

You can be sure . . . if it's Westinghouse

J1-30323 1-6

Meetings and Shows

Aug. 14-17—

Society of Automotive Engineers Inc. National West Coast Meeting to be held at the Sheraton Hotel, Portland, Oreg. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Aug. 22-25—

Western Electronic Show and Convention to be held at the Cow Palace, San Francisco. Additional information can be obtained from Wescon headquarters, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Aug. 28-Sept. 1—

International Heat Transfer Conference to be held at the University of Colorado, Boulder, Colo. Sponsors are American Society of Mechanical Engineers and American Institute of Chemical Engineers; also participating are American Society of Refrigerating and Air Conditioning Engineers, Chemical Institute of Canada, Engineering Institute of Canada, Institute of the Aerospace Sciences, Society of Automotive Engineers Inc., and the University of Colorado. Papers will be presented by engineers from 13 countries. Additional information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

Sept. 5-8—

Association for Computing Machinery. 16th National Conference and First International Data Processing Exhibit to be held at the Statler-Hilton Hotel, Los Angeles. Further information is available from Benjamin F. Handy Jr., Litton Systems, 5500 Canoga Ave., Woodland Hills, Calif.

Sept. 11-14—

Society of Automotive Engineers Inc. Heavy-Duty Vehicles Meeting, including production forum and engineering display, to be held at the Milwaukee Auditorium, Milwaukee. Further information can be obtained from SAE, 485 Lexington Ave., New York 17, N. Y.

Sept. 11-15—

Instrument Society of America. Sixteenth Annual Instrument-Automation Conference and Exhibit to be held at the Biltmore Hotel and Memorial Sports Arena, Los Angeles. Further information is available from Meetings Manager, ISA, Penn Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pa.

Sept. 14-15—

American Society of Mechanical Engineers-American Institute of Electrical Engineers. Engineering Management Conference to be held at the Roosevelt Hotel, New York. Additional information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

Sept. 24-27—

American Society of Mechanical Engineers. Petroleum Mechanical Engineering Conference to be held at the Muehlebach Hotel, Kansas City, Mo. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 25-28—

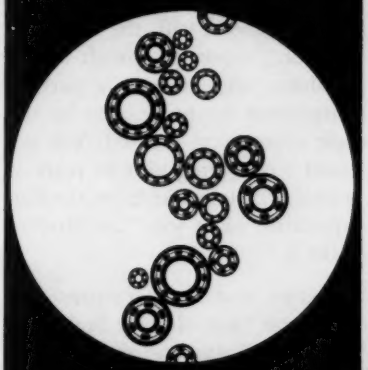
American Welding Society. Fall Meeting to be held at the Adolphus Hotel, Dallas. Additional information is available from Information Center, AWS, 33 W. 39th St., New York 18, N. Y.

Oct. 5-8—

American Society of Industrial

"Try not to make him nervous. It's the first time he's ever tried to put a man in space."

new
LOW COST
ABEC 3 PRECISION MINIATURE BEARINGS



MINA
Bearings eliminate both economic and technical barriers to using precision miniature ball bearings in a wide variety of industrial and commercial products

MADE IN U.S.A. BY
MINA
BEARING
A DIVISION OF MPB INC.
KEENE, NEW HAMPSHIRE, U. S. A.

WRITE TODAY FOR CATALOG

←Circle 218 on Page 19

Circle 219 on Page 19

LET MUELLER MAKE IT!

Mueller Brass Co. of Port Huron is much more diversified than the name "Brass" implies . . . a lot more. In fact, because of its many and varied facilities . . . its *men, methods* and *metals* . . . Mueller is in the unique position of being able to offer true single source service.

MUELLER HAS THE MEN . . . experienced engineers with the ability to work out, creatively, tough design problems, and improve a part or components for production by the most economical method. You get sound engineering plus 44 years of practical metalworking production experience when you "Let Mueller Make It."

MUELLER HAS THE METHODS . . . when you "Let Mueller Make It", you are utilizing one single source that is able to produce parts any one of these ways: as forgings, impact extrusions, sintered metal parts, screw machine products, formed tube or as castings.

MUELLER HAS THE METALS . . . and the materials . . . to produce precision parts in aluminum, brass, bronze, copper, iron, and steel in hundreds of different alloys to meet each exact requirement.

In addition, Mueller Brass Co. has complete and modern facilities for performing all types of finishing and sub-assembly operations. Another plus value is nation-wide sales engineering service.

So, in the final analysis, no matter where you fit in the American industrial picture, whether you're making missiles or mowers...and no matter where you're located, it will pay you to LET MUELLER MAKE IT!

MUELLER BRASS CO.
PORT HURON 20, MICHIGAN

Designers. Annual Meeting to be held at the Ambassador Hotel (Oct. 5) and the St. Catherine Hotel (Oct. 6-8). Additional information can be obtained from Richard M. Wilkes & Associates, 521 N. La Cienega Blvd., Los Angeles 48, Calif.

Oct. 9-13—

Society of Automotive Engineers Inc. National Aerospace Engineering and Manufacturing Meeting, including engineering display, to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 9-15—

American Rocket Society. Sixteenth Annual Meeting and Space Flight Report to the Nation to be held at the Coliseum, New York. Additional information can be obtained from society headquarters, 500 Fifth Ave., New York 36, N. Y.

Short Courses and Symposia

July 24-28—

Advanced Topics on Solid-State Masers summer conference, to be held at the University of Michigan, will cover recent developments in the field. Topics include cross relaxation, optical pumping in solids, optical and infrared masers, advanced technology of cavity and traveling wave masers, and applications of maser systems. Further information is available from Engineering Summer Conferences, 126 West Engineering Bldg., University of Michigan, Ann Arbor, Mich.

July 24-28—

Course on Applications of Stress Analysis to Design and Metallurgy, to be presented at the University of Michigan, will cover principles and methods for applying stress analysis to problems of engineering design, material specification, laboratory testing, and field failures. Topics will include static, fatigue, and impact loading; notch sensitivity and stress concentration; size effect; cumulative damage, understressing and overstressing; problems of life expectancy; statistical interpretation of stress and fatigue data. Additional information can be obtained from Engineering Summer Conferences, 126 West Engineering Bldg., University of Michigan, Ann Arbor, Mich.

July 31-Aug. 11—

Summer Institute for Technical Writers and Publishers, sponsored by Tufts University, will emphasize editorial, supervisory, and managerial problems and procedures of governmental and industrial publications departments. Additional information can be obtained from Mrs. Florence N. Trefethen, Assistant Director, 8 North Hall, Tufts University, Medford 55, Mass.

Aug. 13-18—

Seminar on Theoretical Aspects of Magnetohydrodynamics to be held at Pennsylvania State University. Purposes are to present basic principles of plasma dynamics; to introduce the basic macroscopic equations of magnetohydrodynamics; to study phenomena associated with wave motion, boundary layer flow, and plasma instabilities; and to present the fundamentals of plasma propulsion and power generation. Further information is available from the Conference Center, Pennsylvania State University, University Park, Pa.

Aug. 21—

Fifth Symposium of the Welded Electronic Packaging Association to be held at the Palo Alto, Calif., research facility of Lockheed's Missiles and Space Div. Topics will include encapsulants, coatings, and adhesives; metallurgy; advanced joining techniques; test inspection and quality control; welding techniques and manufacture; and reliability. Further information is available from Charles Antony, Lockheed Missiles and Space Div., Sunnyvale, Calif.

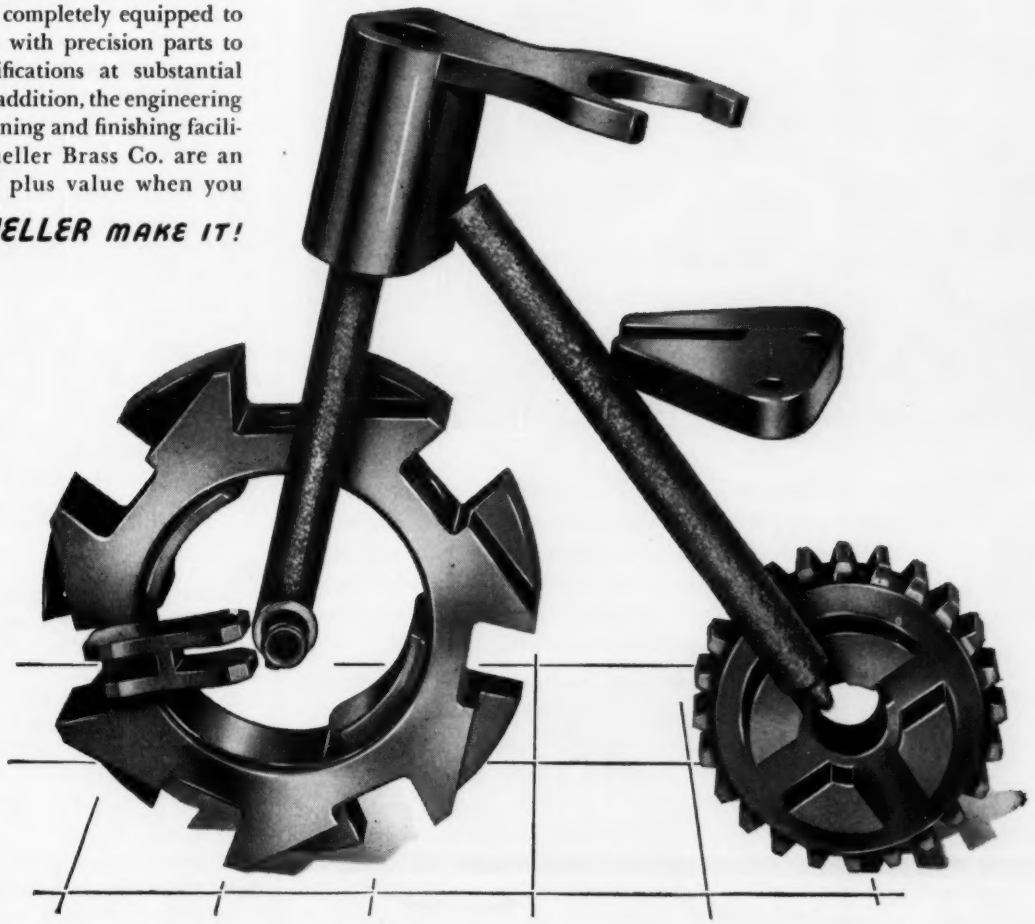
Aug. 21-25; Aug. 28-Sept. 1—

Strain Gage Lectures (first week) **and Strain Gage Laboratory** (second week) courses, to be held at the University of California, will cover both theoretical and practical considerations. Additional information is available from Sam Houston, Engineering Extension, Room 6266 Engineering Bldg. II, University of

MUELLER CAN MAKE MOST ANYTHING IN SINTERED METAL PRODUCTS...

Sintered metal gears, cams, special purpose filters and structural members from iron, nickel, stainless steel, brass and copper alloys are produced by Mueller for practically every segment of American industry. Whatever your product requirements are, the Mueller Sintered Metal Products Division is completely equipped to supply you with precision parts to exact specifications at substantial savings. In addition, the engineering staff, machining and finishing facilities of Mueller Brass Co. are an important plus value when you

LET MUELLER MAKE IT!



MUELLER BRASS CO.
PORT HURON 20, MICHIGAN

339

Circle 220 on Page 19

You name it, Browning has it! Thousands of size and bore combinations in standard Gripbelt sheaves, for use with any of six Browning Gripbelts illustrated in the top row above. Plus five other types of belt drives for various applications: "358", FHP, Variable Speed, Poly-V and Gearbelt. Truly the most comprehensive line in the industry, all immediately available from distributor stock.

Your Browning distributor can help you select the most efficient and economical drive for any requirement. Ask him for details, and a copy of descriptive catalog GC101. Or write BROWNING MANUFACTURING COMPANY, MAYSVILLE, KENTUCKY.

Browning... OUR 75th YEAR

POWER TRANSMISSION EQUIPMENT

California, Los Angeles 24, Calif.

Aug. 23-25—

Fourth Biennial Gas Dynamics Symposium to be held at Northwestern University. Sponsors are the Electric Propulsion Committee and the Magnetohydrodynamics Committee of the American Rocket Society and the Gas Dynamics Laboratory of Northwestern. The program will cover transport properties of plasmas, magnetohydrodynamic wave phenomena, experimental techniques and observations, propulsion, power generation, and thermodynamic properties of plasmas. Additional data can be obtained from Gas Dynamics Symposium, Mechanical Engineering Dept., Northwestern University, Evanston, Ill.

Aug. 27-Sept. 1—

Short Course on Materials Under Thermal Stress to be held at Pennsylvania State University. Object of the course is to present intensive treatment of the present state of the art of thermal stress analysis and interpretation. Lecture topics will include elastic analysis, fundamental behavior of materials under mechanical and thermal strain cycling, inelastic analysis, thermal shock of brittle and ductile materials, and choice of materials and mechanical configuration for optimum design. Further information can be obtained from the Conference Center, Pennsylvania State University, University Park, Pa.

Sept. 5-9—

Short Course on Industrial Photoelasticity to be held at the University of California. Further information can be obtained from Sam Houston, Engineering Extension, Room 6266 Engineering Bldg. II, University of California, Los Angeles 24, Calif.

Sept. 6-8—

Midwest Conference of Fluid and Solid Mechanics, to be held at Michigan State University, will present new research and development work in these two fields. Additional information is available from Dr. Joachim E. Lay, 14 Olds Hall, Michigan State University, East Lansing, Mich.

Sept. 6-8—

Joint Nuclear Instrumentation Symposium, sponsored by Instrument Society of America, American Institute of Electrical Engineers, and Institute of Radio Engineers, to be held at North Carolina State College, Raleigh, N. C. Additional information is available from Meetings Manager, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 12-15—

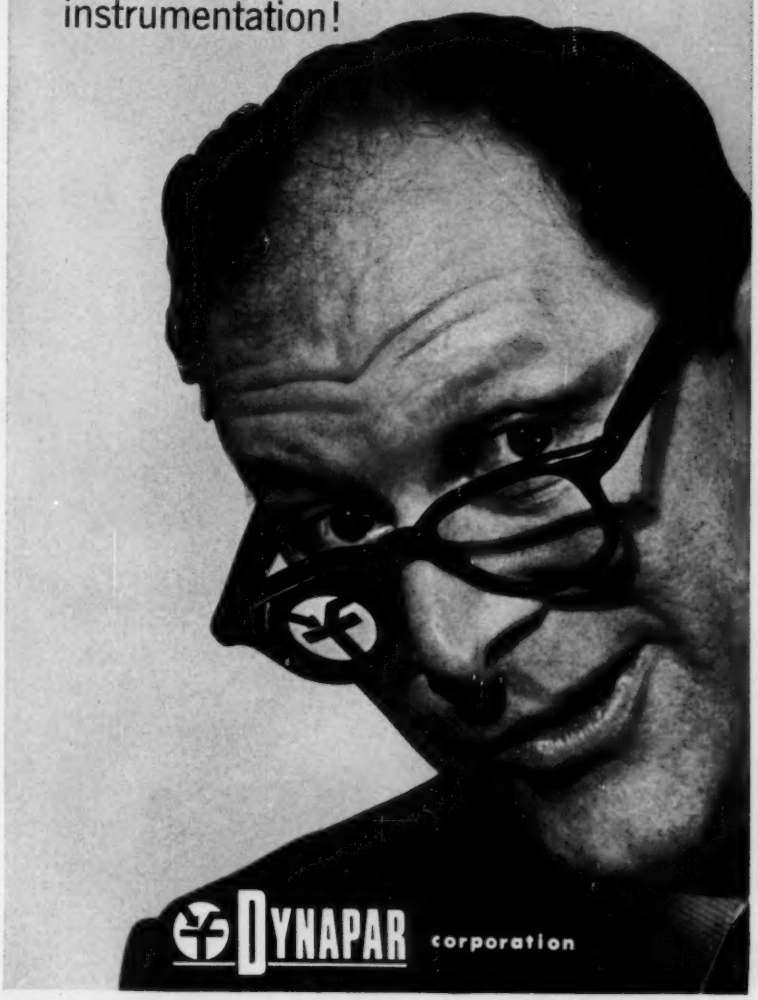
Seminar for Manufacturing Engineers to be held at Pennsylvania State University. It will cover latest techniques related to automation equipment development for engineers responsible for the design, installation, and operation of such equipment. Further information can be obtained from the Conference Center, Pennsylvania State University, University Park, Pa.

Sept. 21-22—

Industrial Electronics Symposium, sponsored by the American Institute of Electrical Engineers, the Professional Group on Industrial Electronics of the Institute of Radio Engineers, and the Instrument Society of America, to be held at the Bradford Hotel, Boston. Theme of the symposium will be supplier-user co-operation. Technical sessions will be on measuring techniques for industry, digital and analog techniques in industry, and new power conversion techniques. Additional information is available from D. J. LaCerda, Badger Mfg. Co., 363 Third St., Cambridge, Mass.

"Who ordered five thousand pounds of lox?"

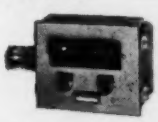
True, 99%
of you don't know
Dynapar from Dinosaur
...but those that do
are getting more profitable results
with our digital control and
instrumentation!



DYNAPAR corporation

Dynapar is the electronic subsidiary of The Louis Allis Co. We make a full line of transistorized digital devices for high-speed counting, measuring, and control.

Information on any of these products can be obtained from your local Louis Allis District Office — which is listed in The Yellow Pages under "Electric Motors."


Draw Indicators

Process Controllers

Rotopulsers

DD-228

DYNAPAR CORP., 459 E. STEWART ST., MILWAUKEE 1, WIS. *A subsidiary of The Louis Allis Co.*

Circle 222 on Page 19

We offer recommendations designed for the application

ALLISPEDE® DRIVE
A low-cost, accurate mechanical drive. Easily adjusts manually or by optional electric remote control. Simple maintenance. Speeds up to 10,000 RPM, speed ranges from 10:1, ½ to 30 HP. Configuration can be readily changed in the field to meet new requirements. Ask for Bulletin 3601.

SELECT-A-SPEDE® DRIVE
Converts incoming AC power to DC output at the motor to provide a highly responsive, precision drive. Drive motors are available in all types of enclosures. Transistorized control panels permit easy field modifications at any time to suit changing conditions. Available in ratings up to 400 HP. Ask for Bulletins 101 and 2001.

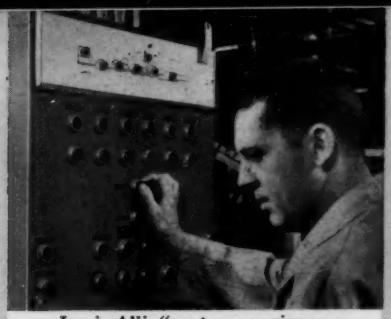
MAGNETIC DRIVE
For applications from 50 to 2500 hp. Liquid cooled magnetic clutch provides precision controlled adjustable speed. Wide speed range with minimum of drift. Available in one, two, three, or four-field construction . . . with or without magnetic brake. Ask for Bulletin 3650.

SYNCRO-RANGE DRIVE
A sophisticated "package system," Syncro-Range Drive from 2 to 200 hp combines an adjustable frequency power supply with compact squirrel cage induction or Syncro-Spede® synchronous motors. Controller offers one-point control of multi-motor process lines. Ask for Bulletins 110, 111, 112.

AJUSTO-SPEDE® DRIVE
Eddy current clutch and a-c motor combination provides stepless, accurate speed control. No brushes, slip rings, or commutators. Simple one-dial control. Sizes ¾ to 100 HP. Offered with wide variety of features including transistor control. Ask for Bulletins 2750 and 2800.

®TM of Eaton Mfg. Co.

NEW design news from Louis Allis



Louis Allis "systems engineering" can provide control for a single process line . . .

or entire plant coordination!

An outstanding line of LOUIS ALLIS adjustable-speed drives from ½ to 2500 hp.

Louis Allis offers you a complete line of adjustable-speed drives with various characteristics for every application where adjustable speed is required.

Experienced Louis Allis field engineers will help you select the best drive for your application. They are supported by regional and factory industry specialists who can recommend a drive system to meet *your* requirements.

The Louis Allis line of drives provides outstanding control features ranging from simple manual to precise electronic or transistorized control. Selection of control varies, of course, with the nature of the installation and the precision required. Where desirable, speed regulation as close as .1% is obtainable.

Controls can be provided which automatically respond to temperature, pressure, or flow. Other control features include threading, inching, jogging, logarithmic acceleration, torque-limit acceleration, tachometer feedback . . . and many other control provisions that can exactly tailor a Louis Allis drive to *your* operation.

For process plants or applications involving inter-related motors and multiple drives, Louis Allis engineers can provide complete "systems engineering" furnishing all electrical rotating components and control.

For expert assistance call your local Louis Allis District Office listed in the Yellow Pages under "Electric Motors" . . . or write direct to The Louis Allis Company, 459 E. Stewart St., Milwaukee 1, Wisconsin. Ask for Bulletin 2900.

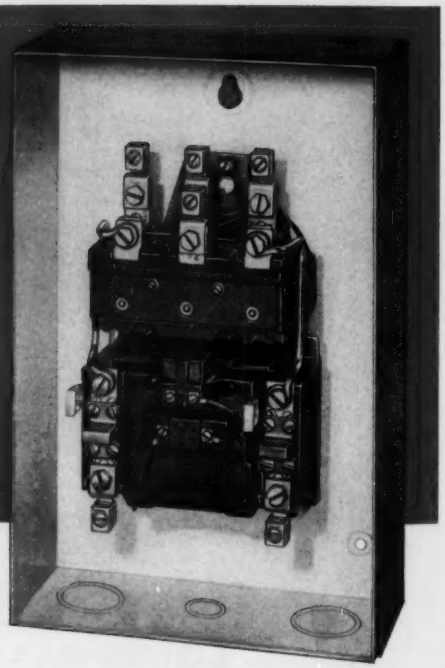
MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

ASD-230

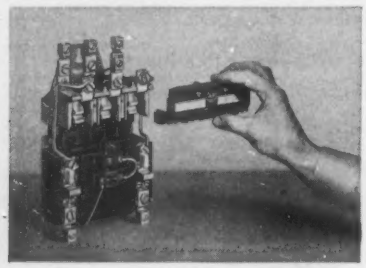
Circle 223 on Page 19

Features of the NEW Allen-Bradley starter line that are of value to you!

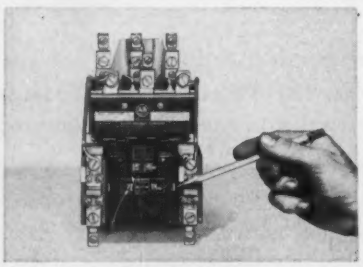


New Bulletin 709 Size 3 across-the-line motor starter. Note the generous space for wiring, accessible terminals, and white interior.

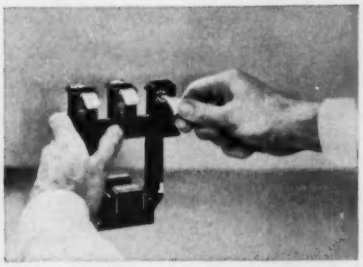
Every detail of the new Allen-Bradley motor starters has been designed to help make this the best line of motor control on the market. Remarkably small in size, each starter is a giant in performance. Being light in weight, these starters are easy to handle and a cinch to install. The generous wiring space, full front wiring, white interiors, and convenient knockouts make installation easy. The enclosure cover is firmly held with a quarter-turn fastener. All installation, inspection, and maintenance operations can be handled from the front—as shown in the illustrations below—without the use of special tools.



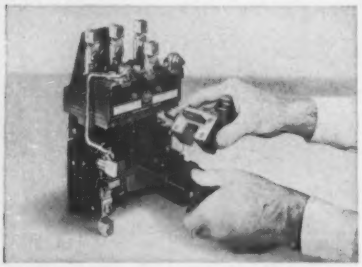
QUICK, EASY CONTACT INSPECTION—When the arc hood front cover is removed by loosening two captive screws, contacts are plainly visible from the front.



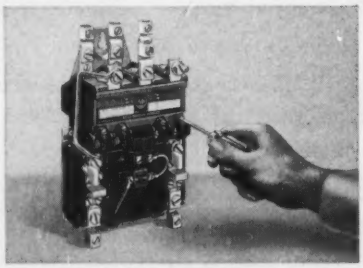
CONTACT POSITION INDICATED—Two slots in the coil cover show the position of the movable contact support—tell whether contacts are "closed" or "open."



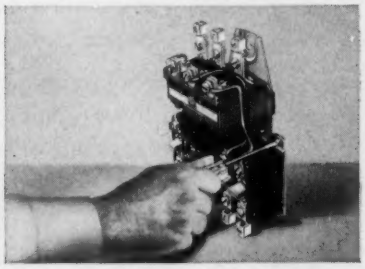
CONTACTS EASILY REPLACED—Depress the spring slightly, and the movable contacts can be lifted out of the molded support and the new contacts slipped in.



COIL EASILY CHANGED—When the coil cover is removed, coil and magnet yoke can be lifted out from the front. They are impossible to replace incorrectly.



AUXILIARY CONTACTS EASILY ADDED to the front of the starter. Two extra auxiliaries can be added to Sizes 0, 1, and 2 starters, and four, to Sizes 3, 4, and 5.

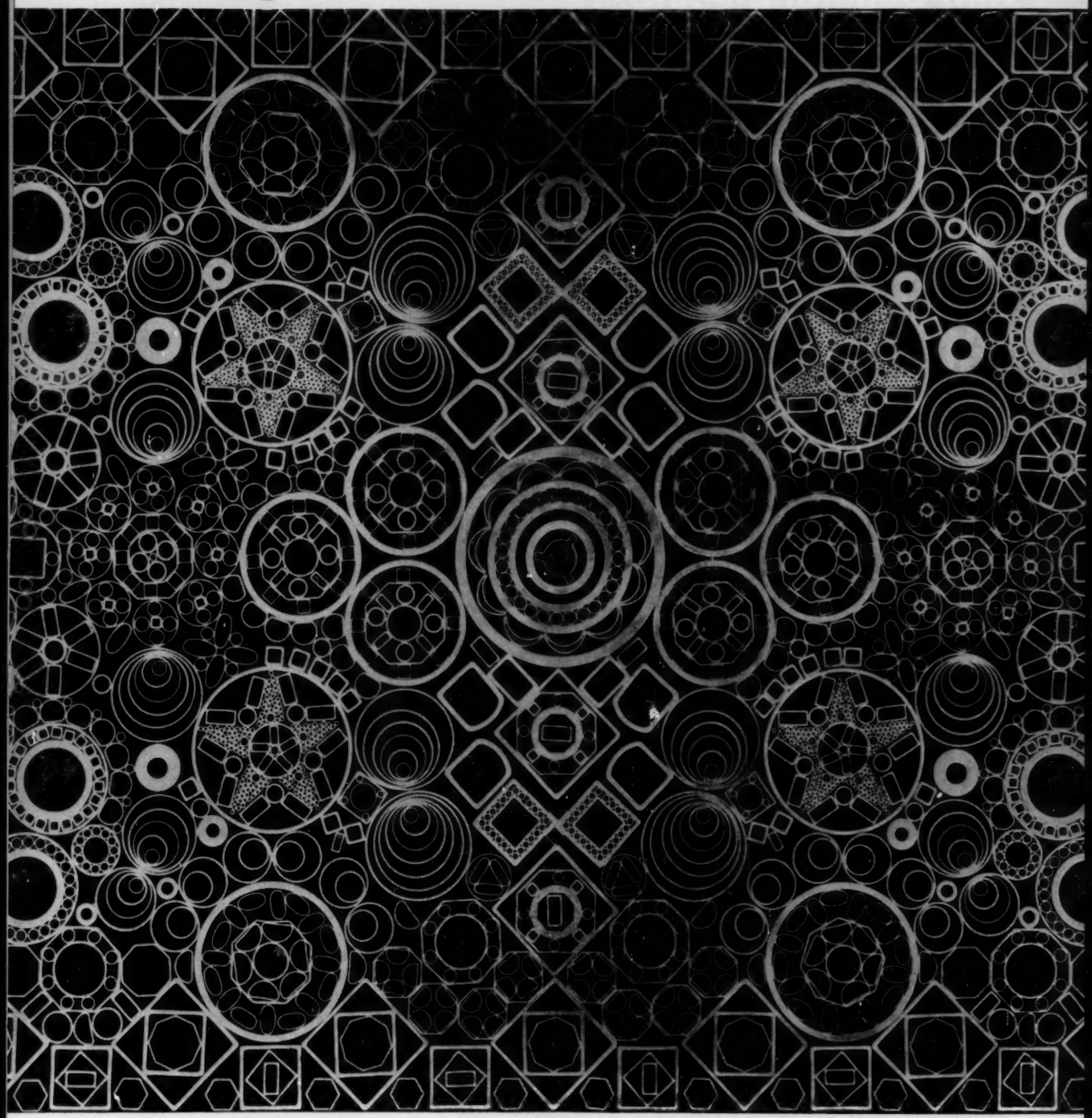


A THIRD OVERLOAD RELAY CAN BE EASILY ADDED in the field, from the front of the starter. And the only tool needed is a common screwdriver.

Allen-Bradley Co., 1333 S. First St., Milwaukee 4, Wis.

ALLEN-BRADLEY QUALITY MOTOR CONTROL

This mark tells you a product is made of modern, dependable Steel.



Seamless Steel Tubing comes in almost every shape and size, that is, if it's **USS National Seamless Mechanical Tubing.**

USS and National are registered trademarks

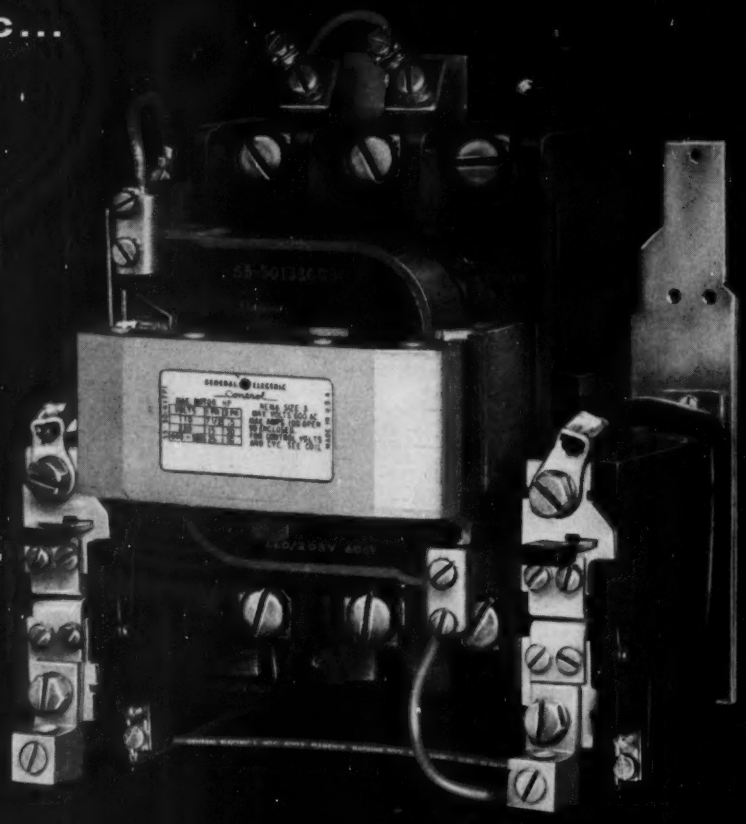
National Tube
Division of
United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors; United States Steel Supply Division; United States Steel Export Company, New York

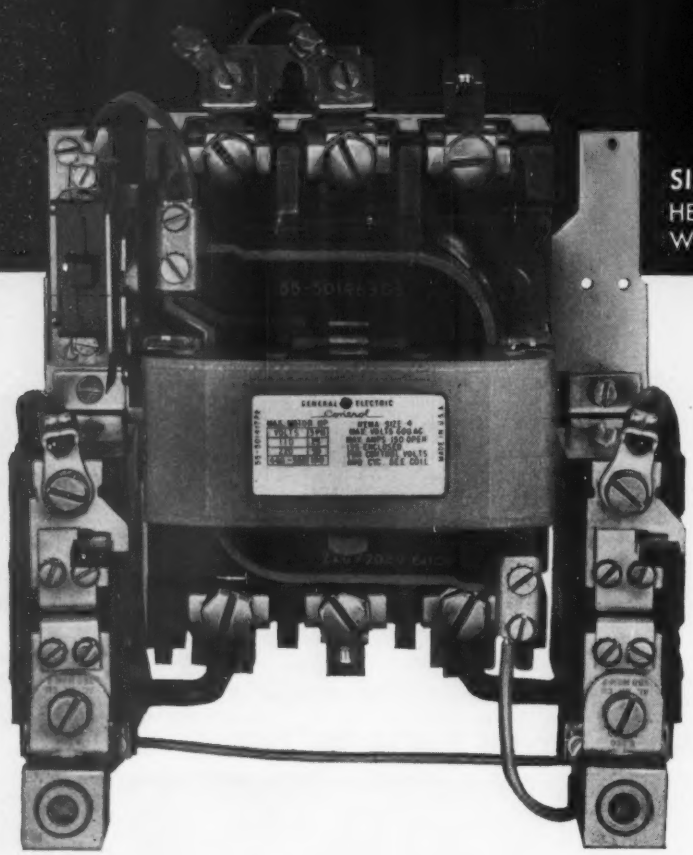
Circle 226 on Page 19

From General Electric...

NEW SMALLER SIZES 3 AND 4 MAGNETIC STARTERS



SIZE 3
HEIGHT—9½ INCHES
WIDTH—8⅝ INCHES



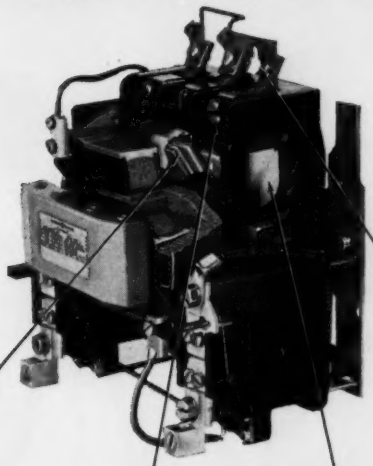
SIZE 4
HEIGHT—10 INCHES
WIDTH—8⅝ INCHES

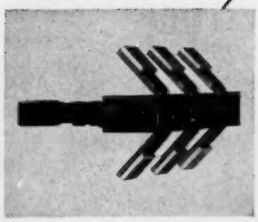
25% HEIGHT

Now General Electric has reduced the height of NEMA Sizes 3 and 4 contactors and starters 25 percent to save you panel material and construction costs. These smaller 100-Line contactors and starters allow you to reduce the size of your control panels. In many cases, you can now mount panels directly on the machines they control instead of building costly floor-mounted panels.

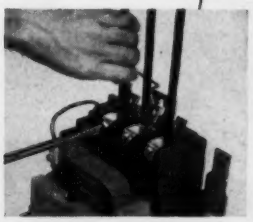
Only 9½ inches high (Size 3) and 10 inches high (Size 4), these starters are about the same height as circuit breakers, disconnects, and other major control components. This means straight wiring runs can be made across the panel with space between troughs determined by other components.

Only General Electric 100-Line Magnetic Starters Give You All These Performance Benefits

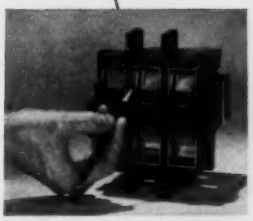




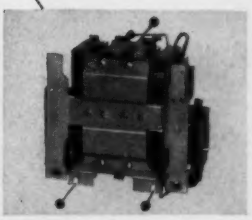
Longer contact life — Unique angled mating of heavy silver-cadmium oxide contacts wipes off contaminants every time starter operates. This reduces arcing and pitting. Shape of 100-Line contacts assures positive "make" with less bounce.



Simplified hook-up — Pressure-type terminals accept 1/0 wire on Size 3 and 250 MCM cable on Size 4. Separate terminal posts contain factory wiring leaving pressure terminals free for your wiring. Terminal posts accept crimp-on connectors.



Improved arc suppression — Magnetic arc trap utilizes circuit breaker method of restricting and quenching arcs. Improved arc cover confines carbon to each separate chamber while exhausting ionized gases that could cause arc restrike.



Easier installation—Starters have three-point keyhole and slot mounting — just hang starter on top screw and tighten. Straight-through wiring on 100-Line starters provides easier terminal identification and connection, shorter wiring runs.

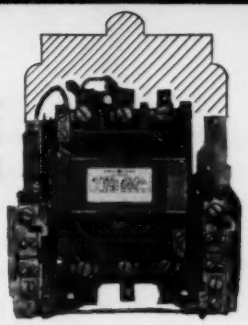
REDUCTION SAVES PANEL SPACE

These new Sizes 3 and 4 starters are also simple to install and wire. The three mounting points are slotted, slip easily over mounting screws, and are readily accessible to power tools. Straight-through wiring, with all line terminals on the top and all load terminals on the bottom, makes hook-up and identification easy, and shortens your wiring runs.

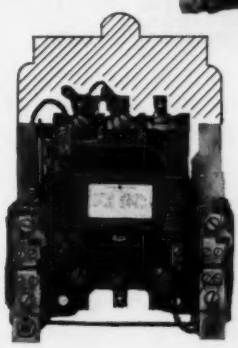
These new starters are part of the 100-Line—a starter design with operational advantages already proved on over *one million* applications.

General Electric 100-Line Sizes 3 and 4 starters are now available, open or enclosed, in all popular forms. Call your G-E sales engineer or distributor, or write for GEA-7326. Section 811-25, General Electric Co., Schenectady 5, N. Y.

You get **MEASURABLE ADVANTAGES** WITH GENERAL ELECTRIC CONTROL



Save 16 square inches with new Size 3. Cross-hatched area shows outline of previous form.



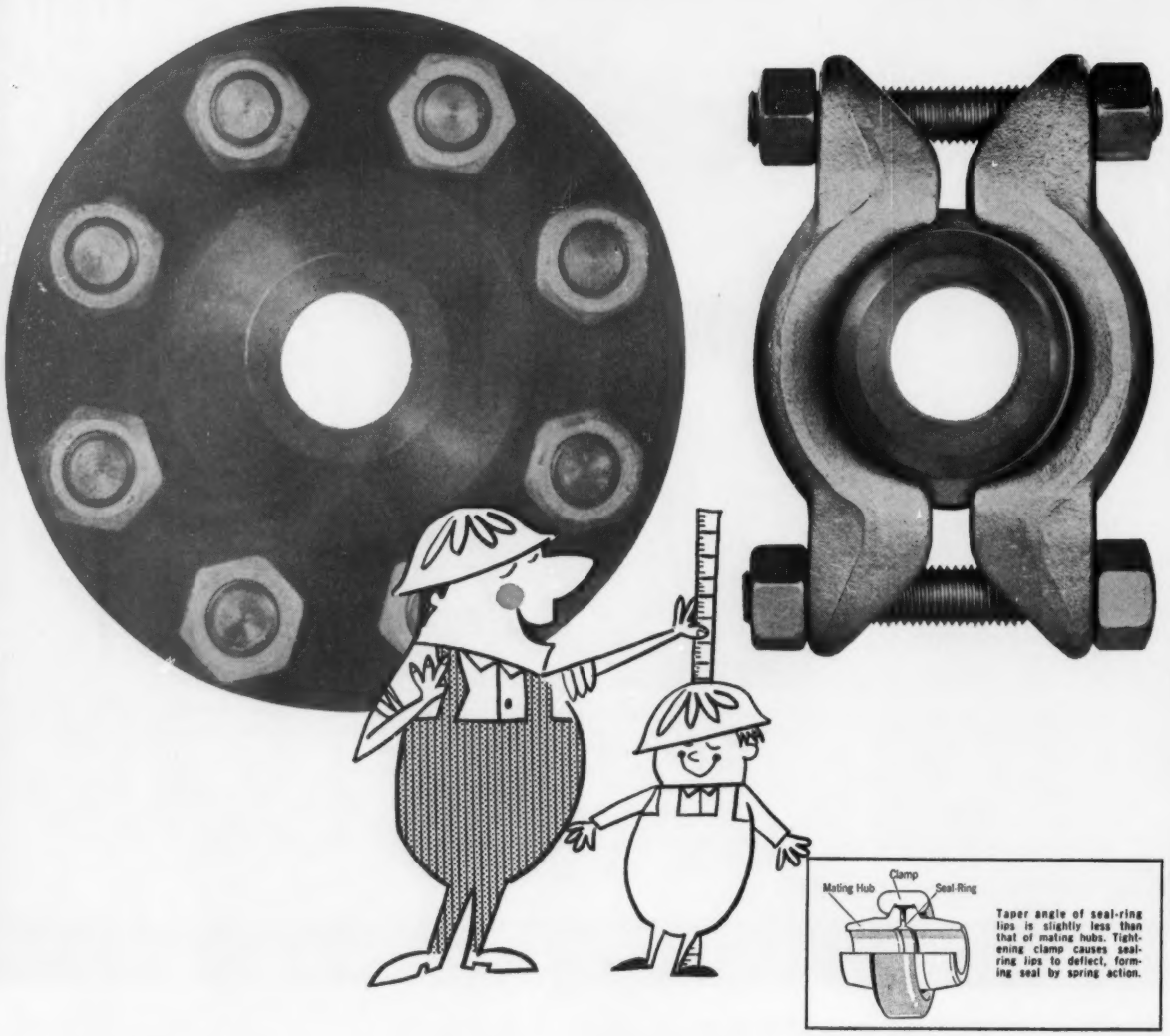
Save 17 square inches with new Size 4. Cross-hatched area shows outline of previous form.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 227 on Page 19

Grayloc Pipe Connections Save ⅓ the Space


Mating Hub
Clamp
Seal-Ring
Taper angle of seal-ring lips is slightly less than that of mating hubs. Tightening clamp causes seal-ring lips to deflect, forming seal by spring action.

GRAYLOC® pipe connections are up to one-third smaller than flanged connections with comparable maximum pressure ratings. They save wasted space—cut unit weight and assembly time drastically.

An all steel assembly, GRAYLOC employs a pressure aided seal that can be assembled or disconnected in minutes. The heart of the assembly—the seal ring—is completely reusable.

Although GRAYLOC connections are manufactured in standard stock sizes from 1″ to 30″, special sizes for special applications are available on request. Corrosion resistant metals can be provided on short notice.

You can use GRAYLOC connections in your piping system. They'll save you maintenance and assembly time, space and money. To learn how, write for the new GRAYLOC catalog.

GRAYLOC SALES DIVISION

GRAY Tool Company

P. O. BOX 2291 • HOUSTON 1, TEXAS • RIverside 7-1240

6112

Circle 228 on Page 19

TESTED for BENDABILITY

Every sheet, coil or tubing shipment of Quaker State aluminum is now certified in writing. It's your assurance that ***your*** order has passed our rigid standards of quality control to meet your exacting specifications.

TESTED FOR BENDABILITY
In this test a piece of metal is bent to a 90° or 180° angle and inspected visually for imperfections. When metal is to be used in a forming operation by the purchaser, only after it has successfully passed this test does it receive the usual Quaker State stamp of "Certified Aluminum."

QS M

HOWE SOUND COMPANY

QUAKER STATE METALS COMPANY

Lancaster, Pennsylvania

A DIVISION of HOWE SOUND COMPANY

Mill Producers of Aluminum Sheet, Coil, Tubing and Extrusions

Circle 229 on Page 19

New Teflon-impregnated asbestos packing becomes standard for all Ohio Brass valves

Ohio Brass Company, Mansfield, Ohio, a leading producer of bronze valves for industry, wanted to standardize on a single packing for its entire line—asked Raybestos-Manhattan, Inc., to develop a suitable all-purpose packing.

Ohio Brass laid down three requirements: (1) it must be resilient and maintain gland torque; (2) must be effective in a wide range of applications; (3) must be priced right.

R/M packing engineers solved the problem with a unique combination of woven asbestos impregnated with Teflon.* Aside from eliminating the need for stem lubrication, this long-wearing packing is inert to the wide range of materials handled by O-B valves.

Whatever your needs in mechanical packings, gasket materials, and specialty products—call on R/M. Our engineering and production capabilities can effect an economical solution for your packing requirements. Send data on your application.

*Registered trademark for Du Pont fluorocarbon resins

RAYBESTOS-MANHATTAN, INC.
PACKINGS
PACKING DIVISION, PASSAIC, N.J.
MECHANICAL PACKINGS AND GASKET MATERIALS

Circle 230 on Page 19

Quick delivery of the Drive you need!

Typical final assembly of A-S Drives from completed sub-assemblies

When you purchase a Square D A-S Drive, you get a complete "package"—including drive motor, operator's station and all controls. You also get these important advantages:

QUICK DELIVERY • Square D's unique method of stocking sub-assemblies means quicker deliveries of packaged drives to meet your requirements.

EASY INSTALLATION • Maintenance manuals are complete in every detail, including step-by-step installation instructions. Moreover, each **A-S Drive** is completely factory-tested and adjusted when shipped — only a few trimming adjustments are needed to put it in operation.

MINIMUM MAINTENANCE • Industrially rated components are used throughout, and extra-sturdy cabinets give lasting protection. Static elements and encapsulated circuits — which are virtually maintenance-free — are utilized wherever possible.

EXTRA SAFETY • Only push buttons with heavy-duty construction and potentiometers with industrial clearances are used in operator's stations, for maximum personnel safety.

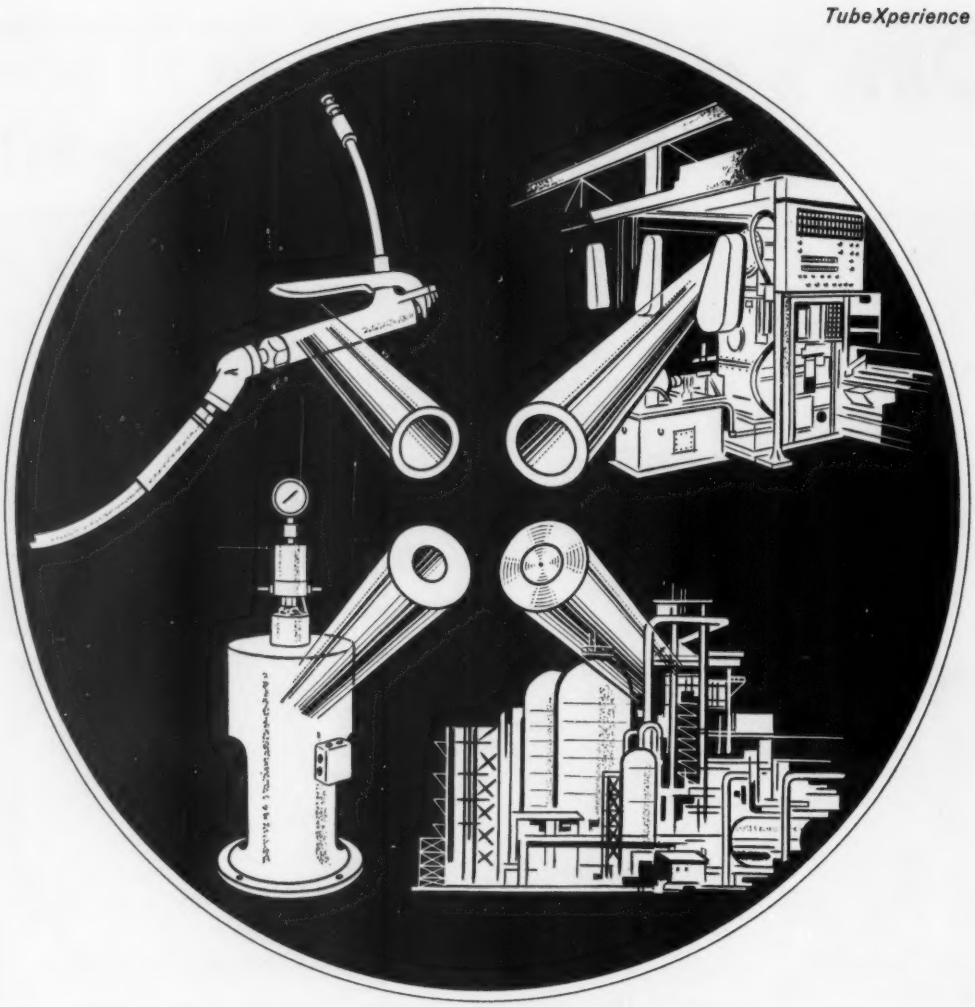
WIDE VARIETY AVAILABLE • There's a Square D "package" for *any* adjustable-speed job. You can choose from electronic, magnetic amplifier or motor-generator types — with ratings from 1/20 to 400 hp — and with accuracies to within fractions of 1%.

FIELD APPLICATION HELP • Square D has wide experience in the design and manufacture of adjustable-speed drives, and field specialists are trained to help you in the selection of the proper drive.

Write FOR BULLETIN • *Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin*

SQUARE D COMPANY

wherever electricity is distributed and controlled



Superior tubing makes pressures behave

whether 125, 5000, 30,000 or 100,000 psi

Superior small-diameter tubing makes pressures behave whether low, medium, high or super. Superior pressure tubing can be roughly divided into two groups: commercial pressure tubing for use in a range up to 20,000 psi; premium super pressure tubing to handle pressures from 15,000 to 100,000 psi. Both ranges can be handled effectively by a number of different analyses, depending on service requirements. Typical applications for Superior general-purpose pressure tubing include pressure tools, machine tools, heat exchangers and condensers. Superior super-pressure tubing is found in hydrogenation process equipment, high-pressure autoclaves, and pilot plant installations in chemical and oil refining plants.

All Superior pressure tubing offers many advantages. It helps prevent critical failures and downtime. It assures long service life, high fatigue strength, excellent corrosion and chemical resistance. In the range from 15,000 to 100,000 psi, Superior super-pressure tubing is a premium product. It is produced from specially selected raw materials. Inside surfaces are conditioned to remove fissures and other defects. During processing, special degreasing operations are performed, and the inside diameters are conditioned to insure a clear, smooth surface. Two types are available: a single wall mechanical tubing and a double wall, or composite unit, made from two thinner tubes. It is produced in an annealed condition and in ⅛ hard temper, and to mechanical properties specified by the customer. All Superior pressure tubing is 100% hydrostatically tested to recommended working pressures, and rigidly inspected for defects.

We can probably help you with any tubing problem that may confront you . . . in pressure, super-pressure or other applications. Contact us and feel no obligation. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

Circle 232 on Page 19

Circle 233 on Page 19→

working with

Du Pont Zytel®

NYLON RESIN

one of Du Pont's versatile engineering materials

New lockset designed with ZYTEL® NYLON RESIN offers easy installation...lifetime service...economical production

This lockset looks better, lasts longer than the metal one it replaces—and it took a material with remarkable properties to make it. It took a material that is exceptionally tough and abrasion-resistant, a material with friction so low as to make lubrication unnecessary, a material that is rust- and corrosion-proof, a material that can be economically molded to close tolerances in large quantities, and one that requires little or no finishing.

In short, it took Du Pont ZYTEL nylon resin.

In this radical design innovation, almost all working parts except the knobs are molded of tough Du Pont ZYTEL. Installation of the lockset is made foolproof; round and square sleeves mate with round and square posts. The entire set is held by two double lead bolts that drive directly into holes in the chassis sleeves. And a self-aligning latch case lets the installer swivel the latch to the right or left of the central lock assembly for bevel-edged doors or for improper boring. In action, the bolts of ZYTEL were tested up to 1,500,000 cycles—equivalent to more than 100 years of normal household use—without perceptible wear. And the lockset functions smoothly and quietly without lubrication. Molded by Nylon Products Corp., affiliated with F. J. Kirk Molding Co., Clinton, Mass., for Lockwood Hardware Manufacturing Co., of Fitchburg, Mass., the parts are economically mass-produced, need virtually no finishing operations.

On the following page, you will find further illustrations of the design improvements and cost reductions made possible by the complete line of ZYTEL nylon resins.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING

...THROUGH CHEMISTRY

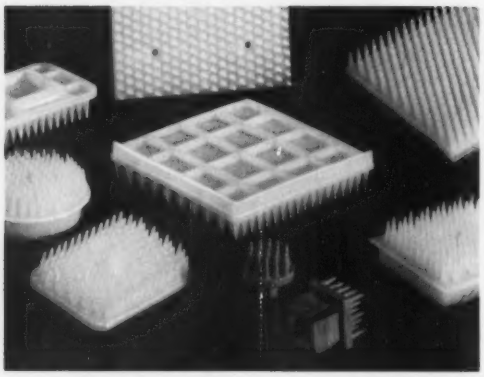
working with

Du Pont Zytel®

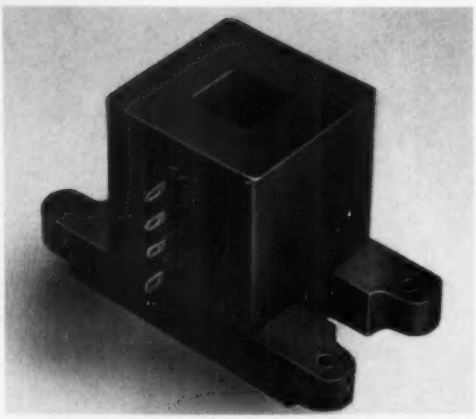
nylon resins

one of Du Pont's versatile engineering materials

When installed in a teletypewriter, these wheels will be subjected to steady abrasion on the typewriter ribbon. The wheels are molded of ZYTEL, because of its impact and abrasion resistance, as well as its moldability and the exacting tolerances which can be held. (Molded by General Die Mold, Chicago, Illinois, for Kleinschmidt Division of Smith-Corona Marchant, Inc., Deerfield, Illinois.)



Heavy loads are supported by small carpet protectors made of ZYTEL. Support is distributed by the many tiny nylon "icicles" that reach the floor between the tufts of rug—instead of crushing the rug under the object's weight. Factors in the choice of ZYTEL were strength and resistance to creep or cold flow. (By United States Caster Cup Corporation, Kansas City, Mo.)



Coils encapsulated in ZYTEL offer high dieletric strength with relatively thin coatings. Coils are protected against humidity, acids, alkalies, and oils. The coatings can also be used as bearing surfaces, as in solenoids and contactors, thanks to the abrasion resistance and low friction of ZYTEL nylon resin. The mounting feet shown are molded as an integral part of the encapsulation. (Processed by Anderson Controls, Franklin Park, Illinois.)

Parts of ZYTEL® NYLON RESIN resist abrasion, stand up to impact, mold easily

A large part of the ZYTEL success story is attributable to its versatility of application. In complete operating units or in working parts, its remarkable array of properties—mechanical, chemical, electrical and processing—makes it a natural problem solver in design. Your own design may well benefit from the contribution of a particular compcsition of ZYTEL. To learn more about the performance of the different compositions of Du Pont ZYTEL, just complete and mail the coupon below.

POLYCHEMICALS DEPARTMENT

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

E. I. du Pont de Nemours & Co. (Inc.), Dept. 2
Room 2507Z, Nemours Building, Wilmington 98, Delaware.

Please send me more information on Du Pont ZYTEL. I am interested in evaluating this material for: A B

_____

_____

Name _____ Position _____

Company _____

Street Address _____

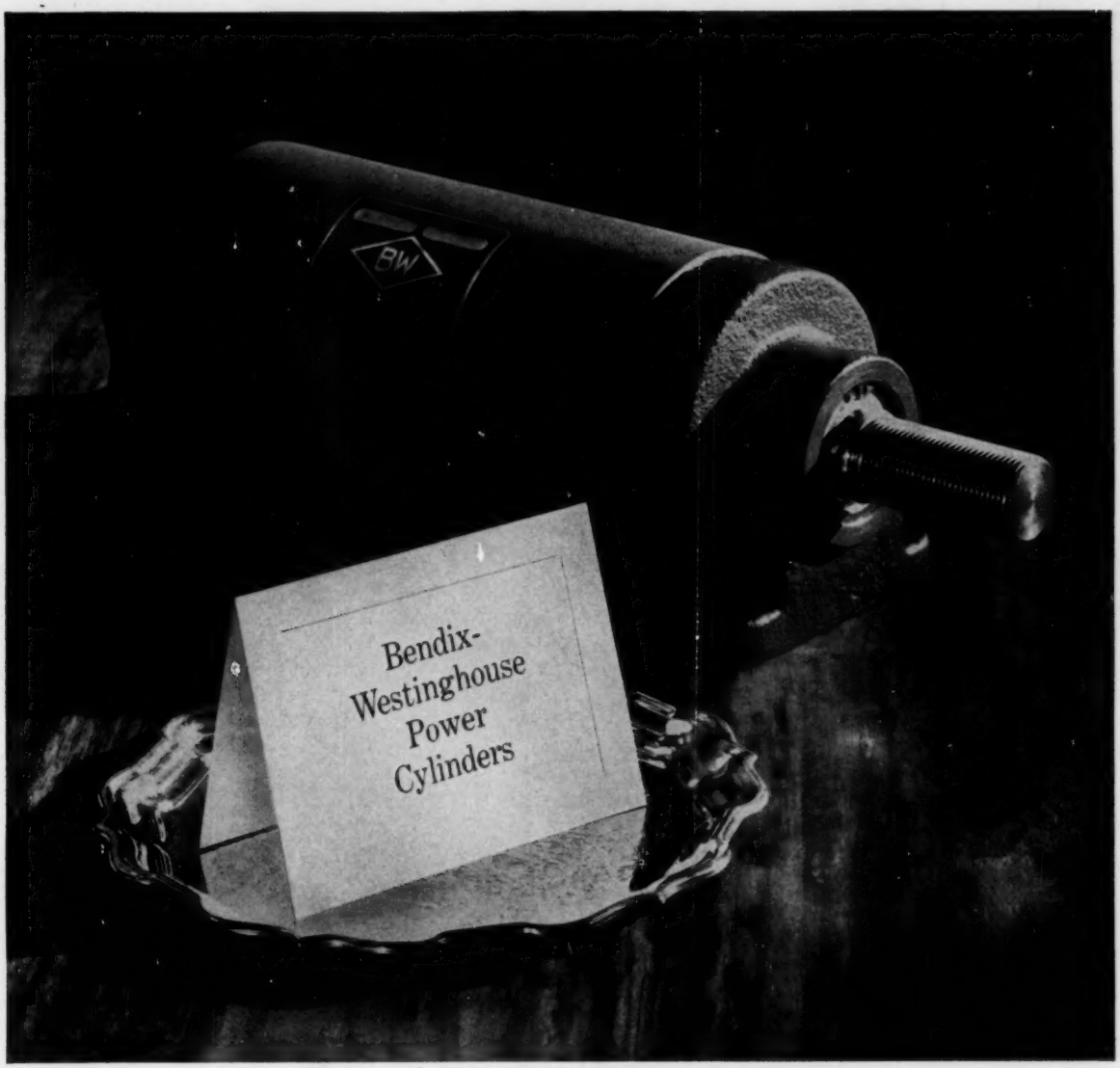
City _____ Zone _____ State _____

Type of Business _____

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec

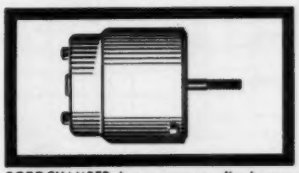
ZYTEL® *nylon resins*

Alathon® · Delrin® · Lucite®

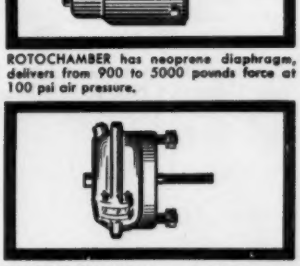


Dependable name, dependable product

The Bendix-Westinghouse name on a power cylinder is your assurance of dependable performance. And, whatever your application, the wealth of Bendix-Westinghouse design experience permits exact "tailoring" to your needs. Bendix-Westinghouse piston-type power cylinders are widely used in every field of industry, operating up to 200 psi air and 1800 psi oil. Our large inventory of machined parts for standard units, combined with our manufacturing flexibility, means fast delivery to meet your needs. In addition to the broad range of standard models, we also provide many specialized sizes and mounts. When you think of power cylinders, think of Bendix-Westinghouse . . . *for dependability!* Write today for complete information.



ROTOCHAMBER has neoprene diaphragm, delivers from 900 to 5000 pounds force at 100 psi air pressure.



ROBOTAIR CHAMBER has optional rubber or neoprene diaphragm, delivers from 300 to 3600 pounds force at 100 psi air pressure.

Bendix-Westinghouse BW

INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

←Circle 233 on Page 19

Circle 234 on Page 19

Now—Fatigue Performance Formerly Available Only in Specials!

...with New UNBRAKO K16 Socket Head Cap Screws

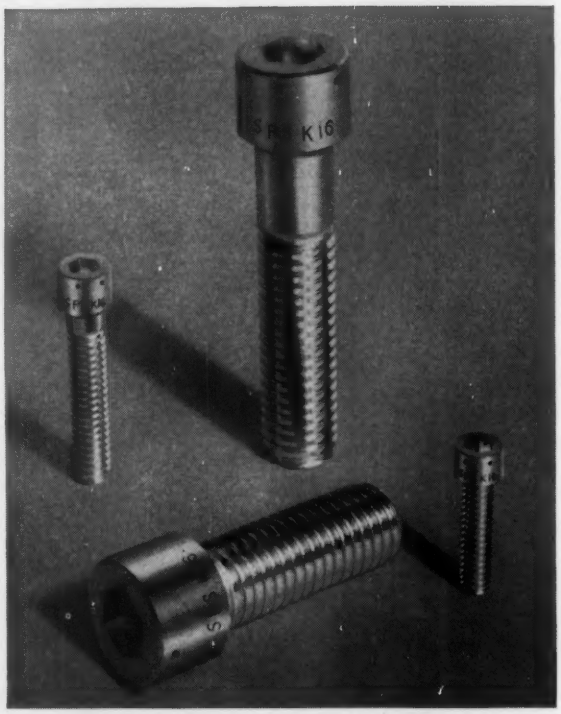
If you have socket-head applications demanding extra-normal fatigue capacity . . . if you have been using costly specials to get fatigue strength . . . here at last is a standard fastener designed specifically to solve your problem.

New UNBRAKO K16 socket head cap screws give you *a bonus of 300% more fatigue life.*

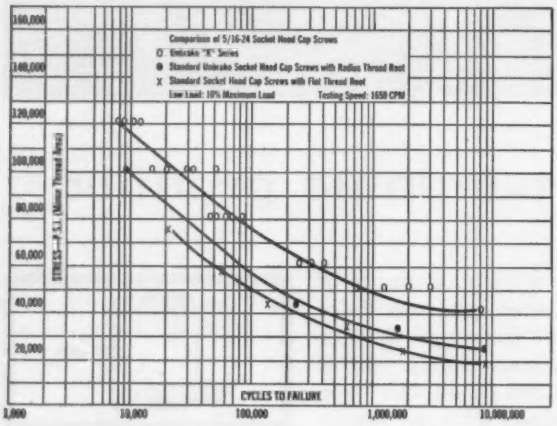
How does SPS achieve this special fatigue performance in a standard fastener? Primarily through extra operations during manufacture. Among them—

- Threads rolled *after* heat treat for extra fatigue strength
- Head-to-shank fillet area cold worked after heat treat to increase fatigue resistance
- Shank precision ground after heat treat to insure no decarburization and for closer body tolerances
- Magnetic particle inspection per SPS Specifications and MIL-I-6868 to insure a reliable product
- These features are in addition to the proven UNBRAKO pHd* head, which delivers far greater holding power, and the SPS Hi-Life thread root form, which reduces stress concentrations . . . both standard on all UNBRAKO socket head cap screws.

*proper Head design



New K16 tension fasteners were developed by SPS to replace costly specials in a growing number of critical industrial applications demanding extra-high fatigue capacity. Cross drilling is standard.



Tension-tension fatigue tests by SPS Laboratories show new UNBRAKO K16 socket head cap screw offers *twice* the fatigue life of regular UNBRAKOS.

Case histories show that 90% of today's fastener failures are due to fatigue—a direct result of the trend toward more and more compact designs, with higher performance demanded of fewer or smaller components. New UNBRAKO K16 socket heads help you meet this design challenge . . . without paying for specials.

UNBRAKO K Series fasteners are available currently as socket head cap screws in standard sizes #8 through ½ in. diameter in 8740 A.Q. steel. Other configurations and series to come. See your authorized industrial distributor or write Standard Pressed Steel Co. for new Bulletin 2707. INDUSTRIAL FASTENER Division, SPS, JENKINTOWN 18, PENNA.

SPS

where reliability replaces probability

CUT

LETTERING COSTS IN HALF WITH CLEARPRINT "FADE-OUT" PAPER

GUIDE LINES IN TITLE BLOCKS AND ENTIRE DRAWING

	PART NO	DESCRIPTION
REQD	6304	RM Spring
11/58	ODD DASH NUMBER SHOWN NEXT HIGHER	

DIMENSIONS IN INCHES

FRACTION ±	TOLERANCES .X ±	.XX ±	.XXX ±	ANGLE ±
		.03	.010	

LAYOUT See File 166-A

CUSTOMERS SEE DWG 33644

DATE 6/19/58
DFTMN JN
CHK BJK
MATL Spec. 104
STRESS Std
SUPV L.M.
PROD H.J. Wm C.
APPD 7/2/58

Vertical and horizontal guide lines are always the same on each and every sheet.

Horizontal lines are identically placed on every sheet, allowing you to design your Title Block as above for uniform lettering on every sheet. Horizontal lines on entire sheet save hours of LETTERING AND DRAFTING TIME.

Vertical lines are identically placed on every sheet and provide uniform guides for vertical layout.

Guide lines are on back of drawing surface enabling you to erase and erase without disturbing them!

Available in rolls and sheets up to 42" in width by any length with grids ruled 4 x 4, 5 x 5, 6 x 6, 8 x 8 and 10 x 10 lines to the inch.

CLEARPRINT®

"FADE-OUT" PAPER T.M.
TECHNICAL PAPER
FORMS • CHARTS • GRAPHS
"PRE-PRINT" PAPER T.M.
THERE IS NO SUBSTITUTE
Clearprint is Watermarked For Your Protection

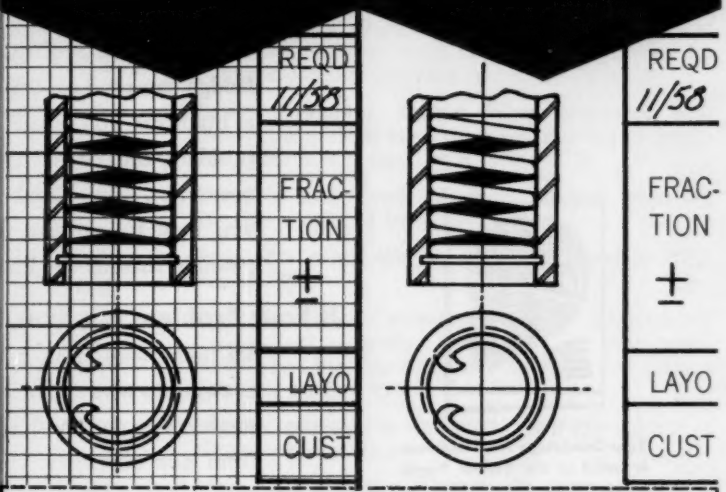
13

HERE'S YOUR DRAWING

Rendered to scale with the accurate blue lines to guide you.

HERE'S YOUR PRINT

Grid lines disappear completely, giving sharp, easy-to-read copies.



CLEARPRINT PAPER CO. MD-258
1482 - 67th Street, Emeryville, Calif.

☐ Send me Clearprint samples, with prices, for the following uses:

_____

_____

☐ Have your representative call at my office to discuss special applications for my particular needs.

Name _____

Firm _____

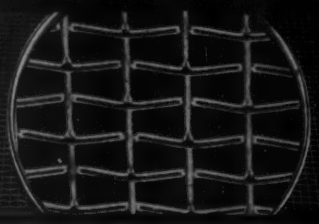
Address _____

City _____ Zone ____ State _____

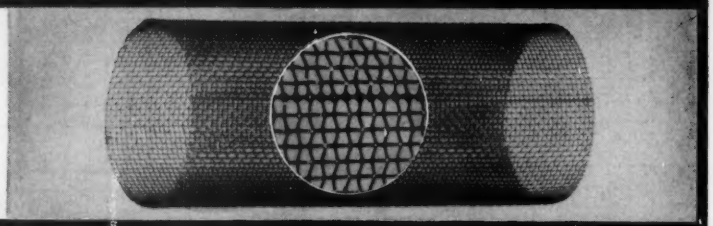
T

Need Wire Cloth Specials? Call *Cambridge*

BRAZED

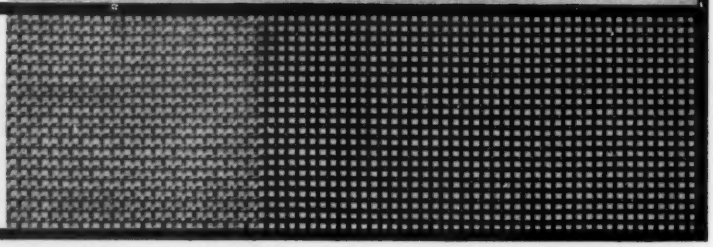


SEAMLESS



TEFLON* COATED

Right Side Coated



*Reg. T.M. of DuPont Company

These are just 3 of the many wire cloth specialties Cambridge can produce for you—no matter how large or small a quantity you need. Or, if you have an extra-special problem, there's an expert on hand to discuss your special needs . . . your Cambridge Field Engineer. He can show you how to get the results you want—in the quickest possible time at the lowest possible cost.

Your Cambridge Field Engineer is listed in the Yellow Pages under "Wire Cloth." Call on him at any time. Or, write for illustrated, 120-page catalog.

If Your Problem Involves Standard Metals or Alloys...

we make wire cloth from any metal or alloy that can be drawn into wire . . . in nine basic weaves, and with accurate mesh count and mesh size. Ask about immediate deliveries from our enormous stocks of the most frequently used types of cloth in a wide range of mesh sizes.

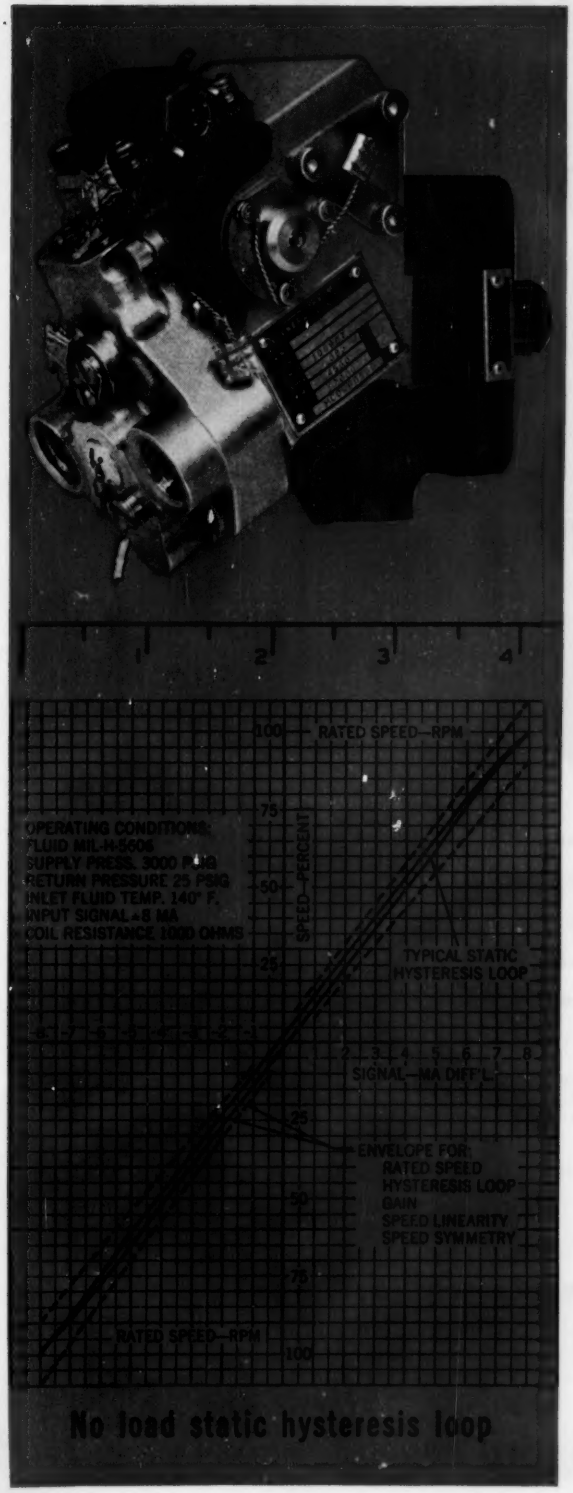
Refer to our technical data sheets in CHEMICAL ENGINEERING CATALOG, Pages 185

THE CAMBRIDGE WIRE CLOTH CO.

DEPARTMENT N • CAMBRIDGE 7, MARYLAND

Manufacturers of Metal-Mesh Conveyor Belts, Flat Wire Conveyor Belts, Wire Cloth, Wire Cloth Fabrications and Gripper® Metal-Mesh Slings.

Performance Guaranteed by Integrated Hydraulic Servo-Motor



Completely new package developed for missile, aircraft and ground support control systems cuts breakaway torque sharply and reduces minimum smooth output speed.

This integrated package consisting of a servo valve and a specially designed, high case pressure hydraulic motor sets a new performance standard for electro-hydraulic servo-motors. Applications requiring continuous, precise output speeds in either or both directions over the entire range are ideally suited to this design. (see chart at left)

Your system requirements will be met precisely with this thoroughly tested package whose basic elements (hydraulic motor and servo valve) have been blended into a compatible operating control-actuator. This condition can seldom be attained when elements provided by two or more manufacturers must be matched. Compared with conventional manifolded components, the integrated Vickers package offers these specific advantages:

Unique Motor Design—High case pressure design eliminates internal axial forces and permits an optimum standby efficiency.

Lower Breakaway Torque—When compared with motors manifolded to servo valves, starting or breakaway torque is reduced by a factor of 8.

Lower Smooth Speed—Minimum smooth speed obtainable is reduced by factor of 5.

Reduced Size and Weight—Weight reduced by 20%; size by 30%.

High Reliability—Contamination can't be introduced during field assembly. Elimination of tube ports, fittings, and bolt-together components further reduces potential problem areas.

High Response—Results directly from low volume of oil under compression.

More Filter Capacity—Control flow to servo valve is filtered by large, self-cleaning, 15 micron nominal filter.

More data is available in Bulletin A 5256. Write for your copy today.

9570

AERO HYDRAULICS DIVISION
VICKERS INCORPORATED
DETROIT 32, MICHIGAN
TORRANCE, CALIFORNIA
division of SPERRY RAND CORPORATION

PROGRAMMED POWER IN: FLUID TRANSFER • POWER TRANSMISSION • ENERGY CONVERSION

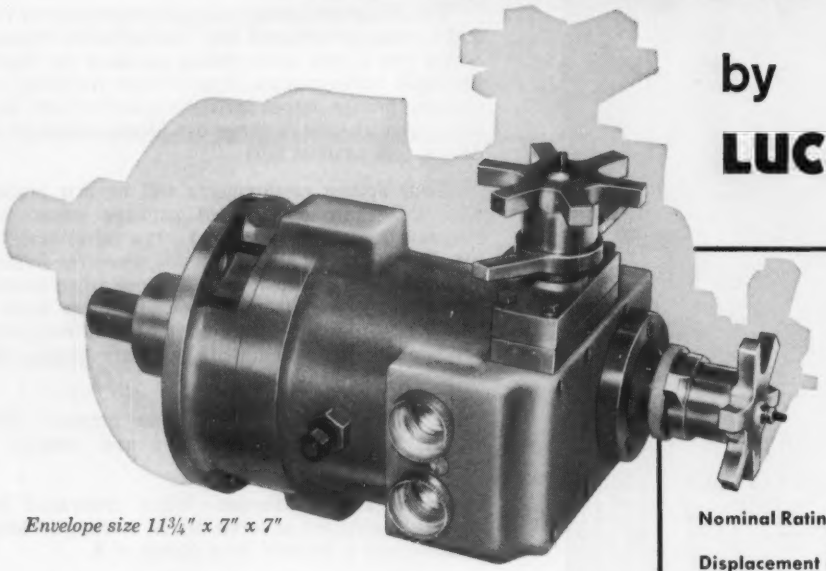
Circle 238 on Page 19

Light-weight, compact and extremely versatile — the reliable

NEW IP 250 INDUSTRIAL HYDRAULIC PUMP

by

LUCAS-ROTAX



Envelope size 11¾" x 7" x 7"

One of the complete new range of quality built hydraulic pumps and motors by Lucas-Rotax, the IP 250 offers many technical advances and advantages. **• Small size • Low weight • Variable volume • Low noise level at higher operating speeds • Low cost • High efficiency • Fitted with integral or remote pressure compensator as standard equipment.**

For further information, contact the agent or office nearest you today, or write for technical literature.

PUMP DETAIL

	Basic Pump Fixed Stroke
Nominal Rating at 3,600 r.p.m.	18 G.P.M.
Displacement (cub. ins./rev.)	1.157
Working pressure up to	5000
(lbs./sq. in.) (continuous)	3000
Speed up to	4000
(r.p.m.) (continuous)	3600
Input h.p. at 1,000 r.p.m. and 1,000 lb. per sq. in. differential	3.32
Weight	29 lbs.
Operating Temperature, °F	−40 to 200
Direction of Rotation	Either
Pressure Compensator Range	500-5000 p.s.i.

a product of creative engineering by

LUCAS-ROTAX LIMITED, TORONTO

LUCAS ROTAX

A member of the Lucas organization
WITH OFFICES AND SERVICE DEPOTS THROUGHOUT NORTH AMERICA

BOSTON • NEW YORK • CHICAGO • LOS ANGELES • HOUSTON • SAN FRANCISCO • CLEVELAND
JACKSONVILLE • DENVER • SEATTLE • BALTIMORE • TORONTO • MONTREAL • VANCOUVER

6005

ROGERS INDUSTRIES

ALUMINUM EXTRUSION DIVISION

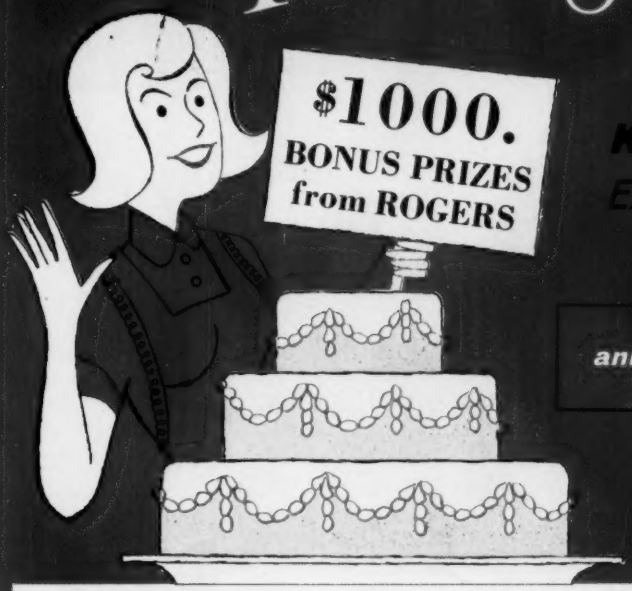
spreads

Frosting on the Cake

for

KAISER ALUMINUM

Extrusion Design Contest!



announcement next two pages . . .

The following two pages introduce you to Kaiser Aluminum's exciting new Aluminum Extrusion Design Contest—prizes total $4,000!

Win any of these cash awards and Rogers Industries adds a Bonus Award to your winnings. $500 1st Prize Bonus; $250 2nd Prize Bonus; Five $50 Bonus Awards.

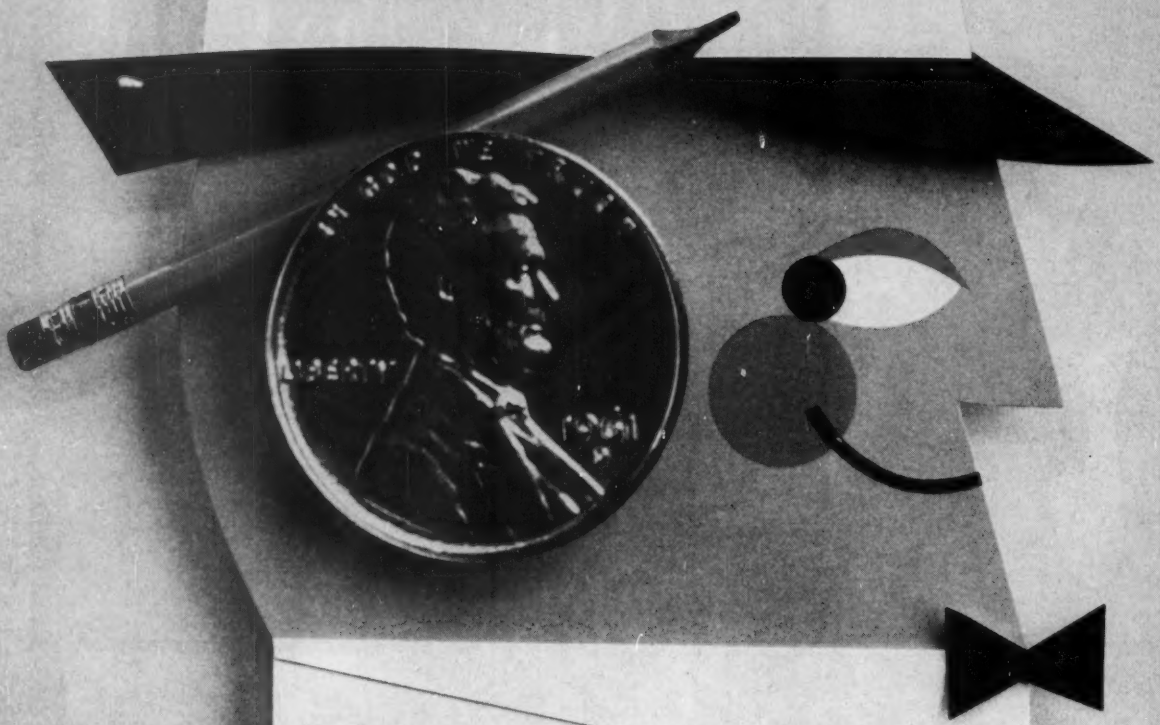
This is "Frosting on the Cake." As a leading extruder of aluminum, this is Rogers' way of helping focus your interest on new cost-saving, product-improving applications of aluminum extrusions.

For Technical assistance, information or help in preparing your Contest Entry, contact Rogers Industries right away.

ROGERS INDUSTRIES

ROGERS INDUSTRIES, INC.
Extrusion Division
14575 Meyers Road
Detroit 27, Michigan

A PENNY FOR YOUR THOUGHTS!



Design an aluminum extrusion, win $2500, $1000 or one of five $100 awards.

SOME WORDS OF ENCOURAGEMENT

It makes no difference whether your design idea is only now budding in your imagination, nurtured on your drawing board . . . accepted, rejected or utilized by your company. All designs using aluminum extrusions are welcome.

Whatever you're designing now, complete product or component part . . . try redesigning it using aluminum extrusions. Maybe a sticky design problem can be solved by developing a never-before-extruded shape that will take the place of a machined, formed or welded assembly, or one that, when sawed into sections, will reduce machining cost . . . or provide other product benefits.

First Place Winner Will Receive $2500. Runner-Up Will Win $1000. And Five Third Place Entries Take $100. each. All Entrants Receive a Bright, New Penny!

THE JUDGES AND HOW THEY CAN HELP YOU WIN

The top twelve designs selected by Kaiser Aluminum will then be finally judged by executives of the Independent Extruders listed on the opposite page. Your entry will be judged on the basis of originality of concept, product improvements, production cost and time savings, and other resultant or projected advantages that aluminum extrusions make possible.

For a better idea of the vast applications for extrusions and for any technical assistance you may need, contact the Independent Extruder nearest you (see list on opposite page). You can call on his and Kaiser Aluminum's vast extrusion experience to give you expert technical guidance in selection of alloys, tolerances, mechanical properties, tooling and extrusion costs.

A PENNY FOR YOUR THOUGHTS!

ENTRY BLANK

1. One $2500, one $1000 and five $100 awards will be made by Kaiser Aluminum & Chemical Corporation for the extrusion designs submitted and judged to be the first, second and five other best designs submitted. Decision of the judges will be final.
2. All designs submitted must be postmarked before midnight August 31, 1961.
3. Each entry and its subject matter shall be the property of Kaiser Aluminum. Entrants accept these rules when submitting their entries, and agree that Kaiser Aluminum may use the entries in any manner without restriction and without payment or any other obligation to the entrant except to the extent set out in Paragraph 1 above.
4. Contest is open to all persons except employees and families of Kaiser Aluminum & Chemical Corporation, Kaiser Aluminum & Chemical Sales, Inc. and independent extruders.
5. No entry will be accepted unless accompanied by a signed contest entry blank, addressed to:

   PENNY FOR YOUR THOUGHTS CONTEST
   Kaiser Aluminum & Chemical Corporation
   Kaiser Center, Room 847, Oakland 12, California

Signature of Entrant_____

Date_____ **Company**_____

Title_____ **Address**_____

City_____ **Zone**____ **State**_____

Additional entry blanks are available from the independent extruder nearest you.

KAISER ALUMINUM

Kaiser Center, Oakland, California

See HONG KONG and MAVERICK weekly, ABC-TV Network

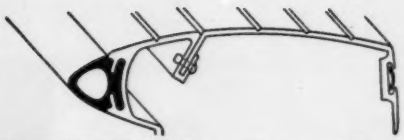
all entrants receive a bright, new penny!
OFFICIAL
ENTRY BLANK
MUST ACCOMPANY
ALL ENTRIES
Design
an aluminum
extrusion,
win $2500,
$1000 or
one of five
$100 awards.
KAISER ALUMINUM

No Contest Is Complete Without Clues

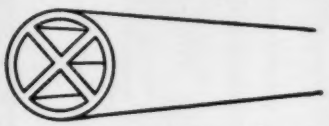
To help you get started on your winning design . . . here are just a few examples of extrusions and the parts they replace.

BETTER HEAT TRANSFER . . . The extrusion process makes possible the integral shape shown at right, above. This design provides greater area for heat transfer and minimizes assembly costs.

LOWER WEIGHT, FASTER ASSEMBLY . . . Several different shapes can often be combined into a single extrusion. The integrally stiffened panel above, right, weighs less, reduces joining cost.



GREATER DESIGN FREEDOM . . . This gunwale provides structural strength as well as good appearance. Made as an extrusion, it provides for interlocking, decorative and utilitarian bumpers as well as color strips. No other process allows the styling and low upkeep possibilities found with Aluminum Extrusions. And extrusion dies are inexpensive compared with tooling costs for other types of fabrication. Fasteners are hidden and no welding is necessary.



LESS MACHINING . . . The low inertia hollow rotating member is manufactured from a close tolerance extrusion. It is sawed into sections from a continuous profile rather than from machined castings or bar stock. The extrusion process reduces expensive tooling, scrap and production time.

Now Start Thinking And Designing...It Could Mean Cash For You!

How To Submit Your Winning Entry.

1. All drawings and descriptions must be submitted on white paper no larger than 16" x 20" with the name of your extrusion design and your name and address typed or printed on the upper left corner of each page. Official entry blank must be included.
2. Each design submitted must clearly show the functional purpose of the extrusion.
3. Include a description of your design, its purpose and advantages and any comparisons between the new design and the product or component it might replace.
4. Photographs of existing components, products or your new design may be submitted along with your entry.
5. Contest entries must be postmarked before midnight, August 31, 1961. Winners will be notified by mail before November, 1961.

CONTACT THE INDEPENDENT EXTRUDER NEAREST YOU

for expert advice on all extrusion problems or for additional entry blanks.

ARKANSAS

Southern Extrusions, Inc.	Magnolia	CE 4-4260

CALIFORNIA

The Aluminum Extrusion Co.	Los Angeles	CL 5-1511
American International	San Jose	CY 8-1606
B & T Metals Co.	Los Angeles	RA 3-4501
Jotaco Extrusions, Inc.	Orange	KE 2-6331
Kawneer Company	Richmond	BE 2-1821
Michael Flynn Mfg. Co.	City of Industry	CU 3-6407
Pacific Extrusion, Inc.	Watsonville	PA 4-2244
Pax Metal Corp.	Van Nuys	TR 3-2720
Texas Aluminum	Mojave	VA 4-4021

FLORIDA

American International Aluminum Corp.	Miami	NE 4-8591
General Aluminum Fabricators	Miami	TU 7-8231
Miami Extruders, Inc.	Miami	OX 1-8900
Regal Extrusion Corp.	Miami	NE 3-8128
Ware Laboratories, Inc.	Miami	NE 4-8511

GEORGIA

Loxcreen Co., Inc.	Chamblee	GL 7-6394

ILLINOIS

Kawneer Company	St. Charles (Chicago)	MA 6-2281
Kinkead Industries, Inc.	Chicago	IN 3-7800
Mala Extrusions, Inc.	Rock Island	788-9321
Precision Extrusions, Inc.	Bensenville (Chicago)	NA 5-4600

INDIANA

Greater Louisville Industries, Inc.	Jeffersonville	BU 2-4341
Mainline Extrusions, Inc.	South Bend	AT 8-9244
Wells Aluminum Corp.	North Liberty	OL 6-8111

IOWA

Titus Metals Corp.	Waterloo	AD 4-1771

MASSACHUSETTS

Northeast Aluminum, Inc.	Lawrence	MU 3-2718
Royce Aluminum, Inc.	Taunton	VA 4-8631
Trim Alloys, Inc.	Boston	AN 8-5200

MICHIGAN

Aluminum Extrusions, Inc.	Charlotte	543-2010
Brazeway, Inc.	Adrian	CO 5-2121
Detroit Gasket & Mfg. Co.	Detroit	KE 1-3400
Ferguson Extrusions, Inc.	Detroit	TE 4-5081
Light Metals Corp.	Grand Rapids	RI 2-3481
Midwest Aluminum Corp.	Kalamazoo	FI 5-8155
North American Extrusions Corp.	Kalamazoo	FI 5-8610
Purpose Extruded Aluminum	Hudson	HI 8-2551
Quality Aluminum Products Co.	Coldwater	BR 8-2381
Rogers Industries	Detroit	VE 8-7500
Valley Metals Products Co.	Plainwell	MU 5-8711

MISSOURI

Hazelwood Engineering & Equipment Co.	Hazelwood (St. Louis)	PE 1-2274

NEW JERSEY

Corson Industries	Delair	NO 2-5500
Mideast Aluminum Corp.	Dayton	DA 9-8113
New Jersey Aluminum Extrusions	N. Brunswick	CH 9-6867
Warner Mfg. Corporation	Bloomfield	PI 8-5000

NEW YORK

Alan Scott Aluminum	Westbury	ED 4-1800
Aywon Wire & Metal Corp.	Brooklyn	TE 9-1000
Badger Aluminum Extrusions	Brooklyn	NI 9-6400
Empire Extrusions Corp.	Garden City Park, L. I.	PI 1-6600
Jarl Extrusions, Inc.	E. Rochester	LU 6-2660
Jasco Aluminum Products Div. of Irving Air Chute Co.	New Hyde Park	FI 3-4300
Jerex Corporation	Amityville	MY 1-7270

NORTH CAROLINA

Carolina Aluminum Co.	Winton	358-4111

OHIO

Alsco, Inc.	Akron	BL 3-7701
B & T Metals Co.	Columbus	CA 8-5411
Calex Corp.	Campbell	PL 5-9679
General Extrusions, Inc.	Youngstown	ST 8-9681
Magnode Products, Inc.	Trenton	YU 8-6331
National Extrusions & Mfg. Co.	Bellefontaine	LY 2-9010
F. A. Pilgrim Co., Inc.	Youngstown	ST 8-4077
Saramar Aluminum Co.	Youngstown	SW 9-9741
F. E. Schumacher Co., Inc.	Hartville	TR 7-9307
Weather-Seal, Inc.	Barberton	SH 5-2114
Youngstown Mfg., Inc.	Youngstown	RI 3-1161

OKLAHOMA

Macklanburg-Duncan Co.	Oklahoma City	JA 8-4411

PENNSYLVANIA

Airmaster	Philadelphia	BA 3-7700
Michael Flynn Mfg. Co.	Philadelphia	FI 2-5500
Penn Brass	Erie	TE 8-1931
Pittsburgh Aluminum Alloys Co.	Pittsburgh	BR 1-4744
R. D. Werner Co., Inc.	Greenville	JU 8-8600

SOUTH CAROLINA

Extruded Aluminum Co., Inc.	Summerville	TR 3-2381

TEXAS

Bauer Aluminum Co.	Dallas	AD 5-2357
Texas Aluminum Co., Inc.	Dallas	RI 1-3361

KAISER ALUMINUM*

*T.M. Kaiser Aluminum & Chemical Corporation

"New leadership in the world of aluminum"

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

RUBBER IN DESIGN ENGINEERING

Whatever shape of rubber part you need, Garlock will produce it most economically and to your exact requirements.

Unmatched facilities enable Garlock to mold, extrude, or die-cut rubber to your specification, ranging from the simplest, more standard shapes and sizes to the closest tolerances and most intricate pieces possible. Experience in mixing, curing, and finishing of different types of rubbers—combined with rigid Garlock quality control and test standards—gives you a rubber part that will do what it was designed to do.

Save money with existing molds and dies. Over the years, Garlock has accumulated thousands of molds and dies. When you place an order for rubber parts, this stock is checked to see if your specifications can be filled from an existing tool; if so, cost of new molds or dies is eliminated, resulting in a savings to you. On the other hand, where new die or mold designs are necessary, your Garlock representative will ask for a sketch or detailed drawing of the part. At your request, Garlock will furnish prototypes from the new die or mold for your approval.

Wide choice of rubbers to select from. No two rubbers react alike to the same conditions—work with your Garlock rubber specialist in picking the right one. Garlock offers a complete line of natural, synthetic and specialty rubbers, one of which is best suited to your application. Call your Garlock representative at the nearest of the 26 Garlock sales offices and warehouses near you. Or, write for Catalog AD-167. Garlock Inc., Palmyra, N. Y.

Canadian Div.: Garlock of Canada Ltd.

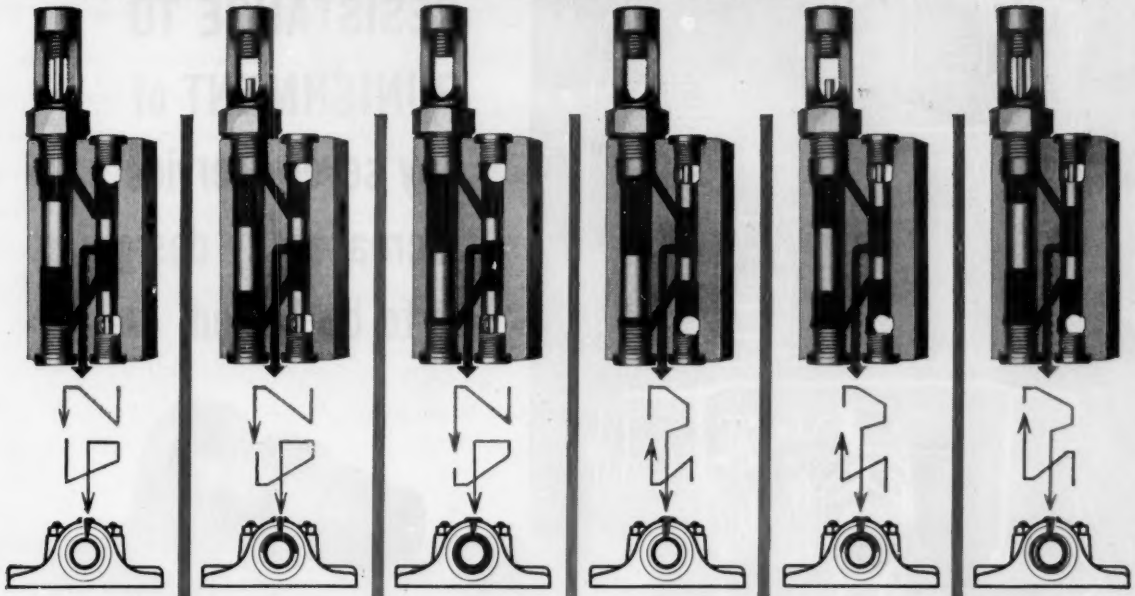
Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

GARLOCK

Here's design simplicity

Farval's Time-Tested Dualine Valve



1

(In red) Lubricant under hydraulic pressure enters inlet at top right — pushing slide valve down and filling upper diagonal passage and chamber above main piston.

(In blue) By this movement, lower head of piston slide valve uncovers lower diagonal passage leading from the main piston chamber. This chamber is full of lubricant from the previous operation.

2

(In red) Lubricant under pressure entering through upper inlet port and into main chamber continues to force main piston downward —

(In blue) discharging lubricant through lower diagonal passage to vertical passage and to outlet port leading to bearing.

3

(In red) Lubricant entering from upper port has now forced the main piston to end of its stroke, and thus the full measured charge below piston has been delivered to the bearing.

Note that Indicator stem has also moved down, indicating main piston has reached end of its stroke, and that no more lubricant will be delivered from this operation.

4

(In blue) Lubricant under hydraulic pressure enters inlet at bottom right — pushing slide valve up and filling lower diagonal passage and chamber below main piston.

(In red) By this movement, upper head of piston slide valve uncovers upper diagonal passage leading from the main piston chamber. This chamber is full of lubricant from the previous operation.

5

(In blue) Lubricant under pressure entering through lower inlet port and into main chamber continues to force main piston upward —

(In red) discharging lubricant through upper diagonal passage to vertical passage and to outlet port leading to the bearing.

6

(In blue) Lubricant continuing to enter under pressure from the lower port has now forced main piston to the end of its stroke, and thus the full measured charge above piston has been delivered to the bearing.

Indicator has reached its top limit, showing the job is done.

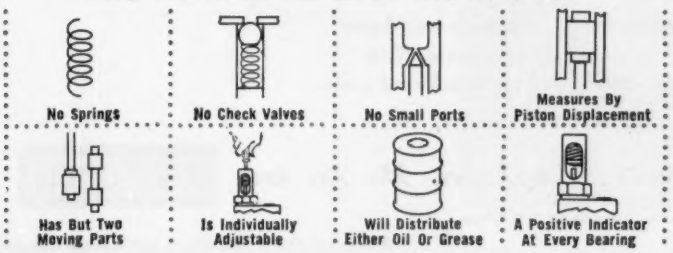
That's why *FARVAL DUALINE* is today's most dependable, positive system of centralized lubrication

Write for free copy of Bulletin 26-T — it gives the complete Farval "Story".

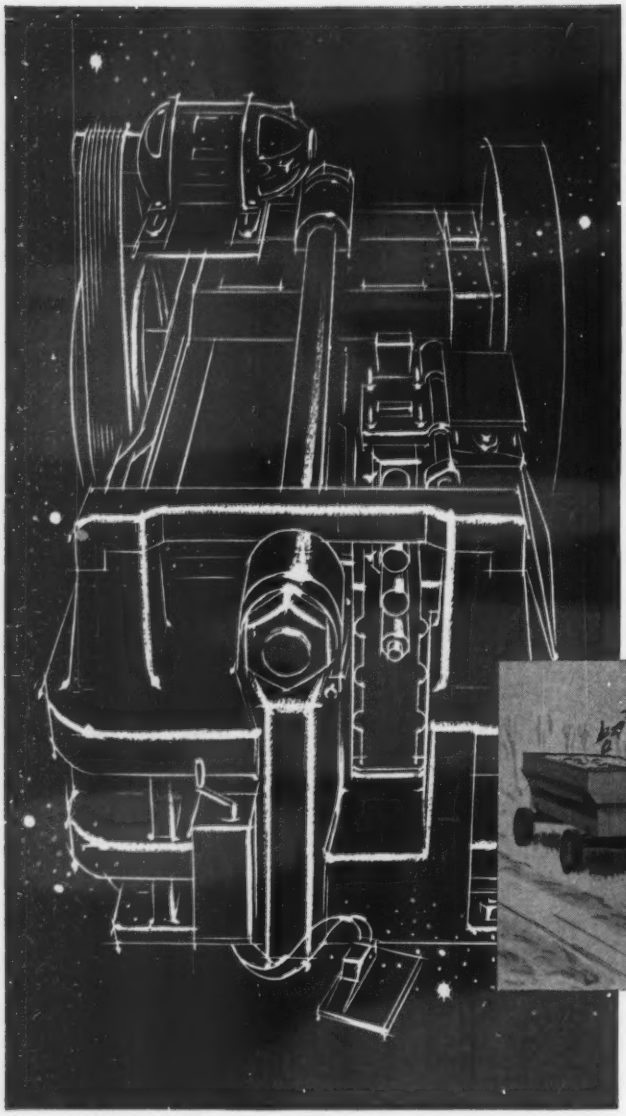
Farval Division
Eaton Manufacturing Company
3278 E. 80th St. • Cleveland 4, O.

Farval Studies in Centralized Lubrication No. 255

Only Farval has all these vital features

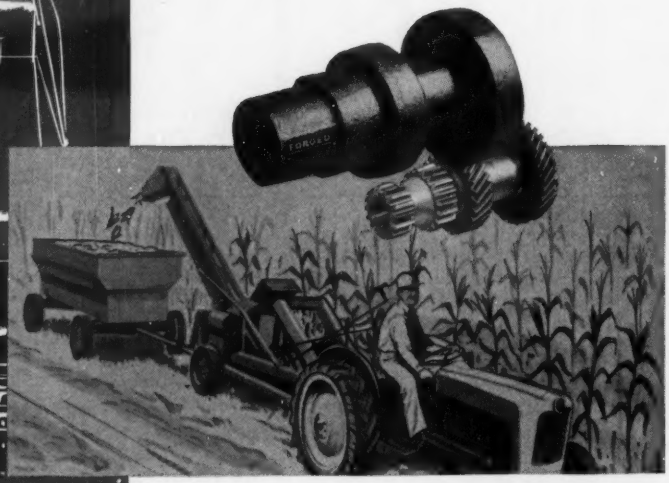

No Springs
No Check Valves
No Small Ports
Measures By Piston Displacement
Has But Two Moving Parts
Is Individually Adjustable
Will Distribute Either Oil Or Grease
A Positive Indicator At Every Bearing

Circle 242 on Page 19



Upsetter, or horizontal forging machine

RESISTANCE TO PUNISHMENT of any severe-service part increased by designing it to be forged



Gear blanks for tractor and farm implement transmissions are designed to be upset-forged, usually with integral forged stub shafts. Forging gives these vital parts maximum resistance to gear-clashing shifts. Transmission life can be equal to equipment life when gears are FORGED.

When you *design with forgings* right from the start, you take full advantage of the many benefits which only forgings offer: highest ratio of strength to weight . . . highest resistance to impact, shock, vibration, torsion . . . preferential orientation of flow lines in the forging to concentrate strength where required . . . absence of wasteful inclusions and voids.

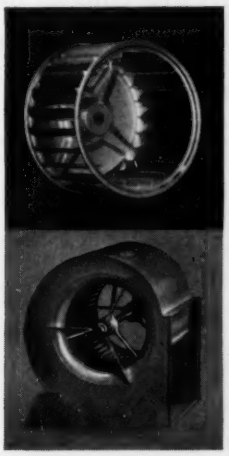
Forged parts start out as *better* metal . . . are made *even better* by the hammer blows or pressures of the forging process. Write for literature to help you design, specify, and procure forged parts.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

EASTERN AIR DEVICES CARLIN COMPANY GILBERT & BARKER MFG. CO. STERLAIRCO DUNHAM-BUSH INC. INTERNATIONAL BUSINESS MACHINES CORPORATION DIEHL MANUFACTURING COMPANY AMERICAN-STANDARD CORP. WELBILT CORPORATION MUELLER CLIMATROL DIVISION WORTHINGTON CORPORATION McLEAN ENGINEERING LABORATORIES YORK DIVISION BORG WARNER CORP. KRAMER TRENTON COMPANY PHILCO CORP. JOHN J. NESBITT, INC. GENERAL ELECTRIC COMPANY POWER VENT DIVISION PROGRESS MANUFACTURING CO. FASCO INDUSTRIES CARRIER AIR CONDITIONING COMPANY REMINGTON CORPORATION ELECTROMODE CORPORATION PARAGON-REVOLUTE DIVISION OF CHARLES BRUNING COMPANY, INC. EATON MANUFACTURING COMPANY BUCKEYE DIVISION OF MARDIGIAN CORPORATION CHROMALOX R. W. BECKETT CORP. IRON FIREMAN MANUFACTURING COMPANY PERFECTION DIVISION HUPP CORPORATION TAPPAN COMPANY STUDEBAKER-PACKARD CORPORATION ARKLA AIR CONDITIONING COMPANY WHIRLPOOL CORPORATION BRYANT MANUFACTURING CO. BENDIX-WESTINGHOUSE CORPORATION McCRAY REFRIGERATOR COMPANY JENN AIR PRODUCTS, INC. MARLO COIL COMPANY INTERNATIONAL OIL BURNER CO. SIEGLER HEATER COMPANY KISCO COMPANY, INC. BOEING AIRPLANE COMPANY THE COLEMAN CO., INC. NUWAY CORPORATION McQUAY, INC. E. L. SCHOFIELD, INC. COLLINS RADIO CORPORATION YORK DIVISION BORG WARNER CORPORATION EUREKA-WILLIAMS CORPORATION AMANA REFRIGERATION, INC. MIDWEST MANUFACTURING DIVISION ADMIRAL CORPORATION LENNOX INDUSTRIES INC. EMERSON-PRYNE COMPANY TRADE-WIND MOTORFANS INC. RECOLD CORPORATION DAY & NIGHT MFG. CO. THE PAYNE COMPANY FRASER & JOHNSTON COMPANY HOLLY GENERAL COMPANY TUCK-AIRE FURNACE COMPANY INTERNATIONAL METAL COMPANY WRIGHT MANUFACTURING COMPANY FRIEDRICH REFRIGERATORS INC. THE MATHES COMPANY VENT-A-HOOD COMPANY FOLSOM COMPANY LARKIN COILS, INC. HEIL-QUAKER COMPANY GENERAL ELECTRIC CO. THE MARLEY COMPANY FORD MOTOR COMPANY McCORD CORPORATION PONTIAC MOTOR DIVISION GENERAL MOTORS CORPORATION CHRYSLER CORPORATION AIRTEMP DIVISION CHRYSLER CORPORATION NUWAY, CORP. MIAMI CABINET DIVISION PHILIP CARY COMPANY THE WILLIAMSON COMPANY COPELAND REFRIGERATION COMPANY WHIRLPOOL CORPORATION AMERICAN MOTORS CORPORATION AUTOMATIC BURNER CORPORATION MODINE MANUFACTURING COMPANY MASTER VIBRATOR COMPANY WORTHINGTON CORPORATION YOUNG RADIATOR COMPANY MOTOR WHEEL CORPORATION REDMOND COMPANY INC. UNIVERSAL ELECTRIC COMPANY VENTROLA MFG. COMPANY COOLERATOR DIVISION McGRAW EDISON COMPANY GIBSON REFRIGERATOR COMPANY JANITROL HEATING & AIR CONDITIONING DIVISION MIDLAND-ROSS CORPORATION NORMAN PRODUCTS COMPANY U. S. AIR CONDITIONING WESTINGHOUSE ELECTRIC CORP. EBCO MANUFACTURING COMPANY NEW YORK BLOWER COMPANY PREWAY, INC. RHEEM MANUFACTURING COMPANY JENN AIR PRODUCTS, INC. KISCO COMPANY CUSTOM-AIRE PRODUCTS DIVISION MINNESOTA MINING & MANUFACTURING COMPANY PURITRON CORPORATION



A CUSTOMER LIST IS OUR BEST ADVERTISEMENT

We design, develop, produce and test — fans, blowers and specialty air moving units — for U.S. industry.

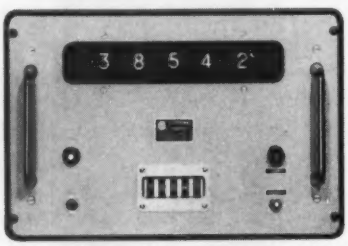
A distinguished customer list is and always will be our best advertisement!

THE TORRINGTON MANUFACTURING COMPANY

AIR MOVING DIVISIONS • TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • ROCHESTER, INDIANA • OAKVILLE, ONTARIO

Circle 244 on Page 19

an electronic high-speed bi-directional counter that's easy to attach, easy to use, easy to maintain. It adds, subtracts, counts up to 5000 per second, recycles instantly. Moderate in cost, it's ideal for a wide range of displacement measurement jobs... on lathes, drill presses, boring mills... on linear or rotary optical comparators. And this is only the beginning of its usefulness. To see what it can do for you write Electronic Controls Division, Veeder-Root Incorporated, Danvers, Mass. **count on... VEEDER-ROOT**



Numerical readout tubes—in five or six digits make the Series A-1805 Electronic Counter easy to read up to 40' away. Transistors and printed circuits assure trouble-free operation. Controls include selector switches, power switch, reset button, pilot light.

FOXBORO
REG. U.S. PAT. OFF.

POWERS CONTROL

Taylor Instruments
MEAN
ACCURACY FIRST
VISION · INGENUITY · DEPENDABILITY

MOORE

BRISTOL'S

A. W. CASH

MASONEILAN

Lawler
MOUNT VERNON, N.Y.

Uniformity and long cycle life earn preference for **Flexonics** bellows with leading control manufacturers

For measurement and control of process variables, the country's leading instrument manufacturers are specifying Flexonics Bellows. Uniformity of effective area and spring rate . . . adaptability to a wide variety of fittings . . . a broad range of sizes and materials . . . and proved long cycle life—are only a few of the many reasons for this strong preference.

A Flexonics Bellows may be the answer to your design problem. Send an outline of your bellows application — the Flexonics Application Engineering Staff will be pleased to study your specific problem and make recommendations. Or, if you prefer, write for the Flexonics Design Guide . . . 20 pages of valuable bellows information.

B-830

Flexonics

DIVISION OF CALUMET & HECLA, INC.
350 East Devon Avenue · Bartlett, Illinois

FLEXIBLE METAL and SYNTHETIC HOSE
EXPANSION JOINTS
BELLOWS · SPECIAL TUBULAR ASSEMBLIES

In CANADA
FLEXONICS CORPORATION OF CANADA, LTD.
BRAMPTON, ONTARIO

FLEXONICS
350 E. Devon Ave.
Bartlett, Illinois

Please send my personal copy of Flexonics 20 page Bellows Design Guide covering in detail Flexonics products and services for bellows applications.

HYDRECO
out front in . . .
ADVANCED PRODUCT DESIGN

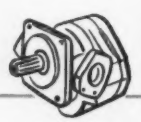
ONE MORE WAY HYDRECO SERVES YOU BETTER!

Apart from the design of production pumps, motors, and valves, Hydreco engineers are continually concerned with the development of special hydraulic equipment for specific applications.

For example, new industrial or mobile equipment sometimes requires modified or even totally new fluid power components. These custom-designed products are developed, tested, and proved right in our own hydraulic laboratory. And once perfected, they are precision manufactured.

This ability to custom design within cost and physical limitations can be applied to your product design problems, too. If you manufacture earth moving, agricultural machinery, materials handling or industrial equipment, take advantage of Hydreco's creative engineering service. It's one more way Hydreco serves you better.

HYDRECO® DIVISION
THE NEW YORK AIR BRAKE COMPANY
KALAMAZOO • MICHIGAN


PUMPS

VALVES

MOTORS

Circle 247 on Page 19

97% of pre-school children tested couldn't open this bottle cap—Since hundreds of young children are poisoned every year by medicines taken accidentally, this percentage is significant. According to the manufacturer, Brockway Glass Company, the safety cap, which looks like a conventional bottle cap, is "the first major improvement in prescription packages in fifty years." Unique in design, it must be pressed down and turned to open—operations that children five and under can rarely perform simultaneously. For them, the cap turns freely without unscrewing from the bottle.

NEW DESIGN WITH TWO PLASTICS ...A CHILD-SAFE BOTTLE CAP

Two BAKELITE® Brand plastics work together in a totally new, much-needed cap for medicines

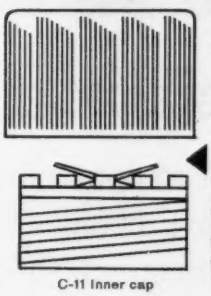
Two plastics help make this design workable—Manufactured for the Brockway Glass Company by Seals, Inc.,* the new safety cap consists of two parts—an outer shell molded of BAKELITE Brand high-density polyethylene, and an inner section molded of BAKELITE Brand C-11, an acrylonitrile-styrene copolymer. There are multiple advantages to this combination—eye appeal, low cost, resistance to chemicals and stress cracking, and durability. The toughness and resilience of both these materials are important mechanical features. Lugs on the inner cap engage those inside the outer cap when pressure is applied. Without pressure, the two leaf springs molded on the inner cap keep lugs from engaging, and the outer cap turns without opening.

Molded details in two tough materials are key to function, low cost—Both the BAKELITE high-density polyethylene and the BAKELITE C-11 plastic used in the cap have a degree of "give"; they are neither brittle nor soft. It is this factor that makes the lugs disengage unless pressure is applied, and it also means that the lugs will not break off or wear down with repeated use, as might happen with a brittle material. The list of molded-in details is impressive—screw thread, lugs, leaf springs, printing, knurling—yet all are readily formed in these plastics with a simple, economical molding operation.

*U.S. Patent No. 2964207

Keep an eye on packaging—it's one of the liveliest areas of design and a source of refreshing ideas. Not only must it keep pace with changing esthetic concepts, but it also involves practical mechanics. This is often the reason why packaging designers have made such bold use of plastics in working out their plans. Plastics can provide properties that differ from those of conventional materials. And since there are differences among plastics, the range of possibilities is far-reaching.

Under the BAKELITE Brand, for example, you can select from five different classes of plastics to fit your needs—polyethylenes, epoxies, phenolics, styrenes, and vinyls. Molded, extruded, laminated, and in coatings, they can be a source of genuine product improvement. And from Union Carbide, you can get expert technical assistance in putting them to the best use. For information, see Sweet's Product Design File, section 2a/ui.



UNION CARBIDE

Dept. JM-84G, Union Carbide Plastics Company
Division of Union Carbide Corporation
270 Park Avenue, New York 17, N.Y.

Please send me information on the use of BAKELITE Brand Plastics in design with particular emphasis on these properties_____.
Application being considered is_____.

NAME _____

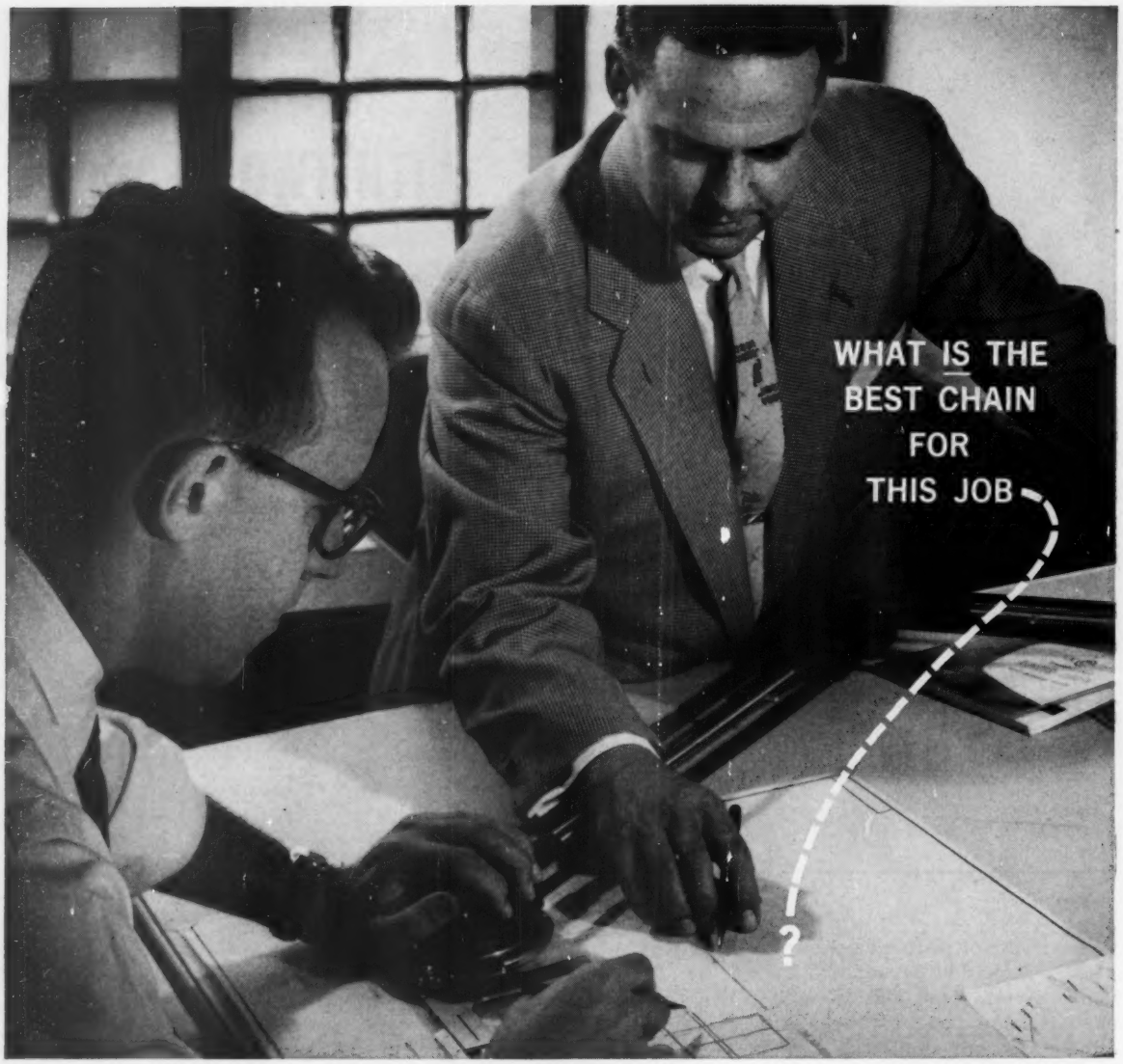
FIRM NAME _____

STREET _____

CITY _____ ZONE ____ STATE _____

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

Circle 248 on Page 19



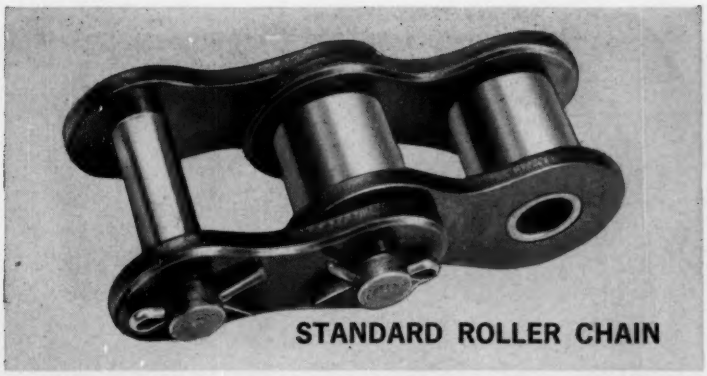
Your chain specialist from Link-Belt

Working with industry's most complete line, he will recommend the best chain to solve your problem—whether it be one of horsepower, space, speed, shock or cost

Our chain specialists have helped manufacturers overcome a wide variety of chain application problems. Their contributions to drive and conveyor design, their ability to recommend chain precisely suited to the job—these are factors that make Link-Belt specialists welcome advisors to design and plant engineers.

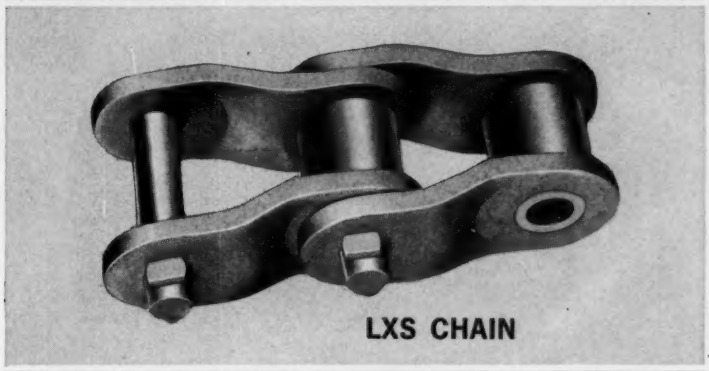
Application experience is important to you, of course. And so is our complete line of drive and conveyor chains and sprockets. From this full line, our engineers can recommend the particular chain which exactly meets your requirements.

This combination of experience and complete line makes Link-Belt your most reliable source for products and service in chain. See the facing page for a few of the many Link-Belt drive and conveyor chains available to you. For further information, contact your nearby Link-Belt office.



STANDARD ROLLER CHAIN

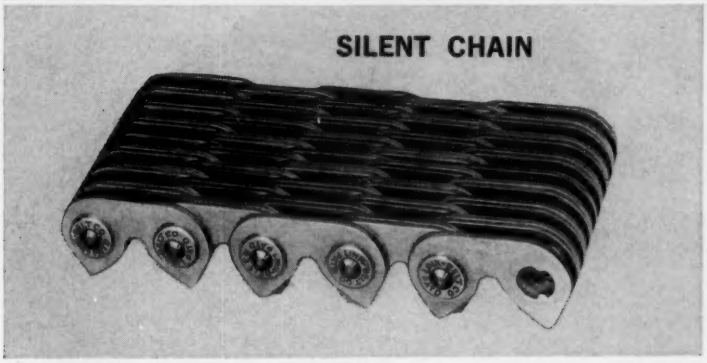
Link-Belt precision steel roller chain for drives and conveyors assures extra-smooth, long-life operation. Sidebars of premium steel are accurately machined and heat treated to resist the *stress-on, stress-off* action of today's high-speed drives. Shot-peening of rollers gives greater fatigue life to withstand impact of sprocket engagement. Other Link-Belt manufacturing "extras" include prestressing of multiple-width chain, close heat-treat control, micro-finish of parts. Single-strand or multiple-strand chains are available in a variety of sizes from ¼" through 3" pitch.



LXS CHAIN

"FULL-ROUND" design of Link-Belt LXS chain eliminates sharp corners, provides economy and efficiency for the most punishing drive and conveying jobs. Its design eliminates stress concentration points encountered with many ordinary chains; stress is distributed evenly, long life assured. Design provides live bearing area between pins and bushings. Use of selected steels and controlled hardening of parts assures exceptional uniformity and endurance. Available with either straight or offset sidebars.

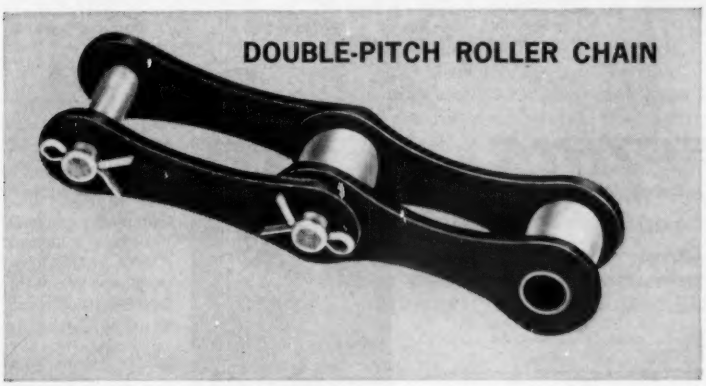
SILENT CHAIN



Silent chain excels where other types of drives are impractical due to slipping tendencies. It assures efficient transmission of power for either large- or fractional-horsepower applications. Easy assembly in tight spaces permits close grouping of equipment to save valuable floor space. High humidity and temperature have no effect on performance. Ratios as high as 10 to 1 are accommodated on relatively short centers. Available in a wide range of sizes from 3/16" to 2" pitch.

simplifies and speeds chain selection

DOUBLE-PITCH ROLLER CHAIN



Link-Belt double-pitch roller chain is supplied in drive and conveyor types . . . 1" through 3" pitch. Drive chains are lighter and cost less than standard roller chain because they have only one-half the number of pins, bushings and rollers. They are ideal for moderate and slow-speed applications having long shaft centers. Conveyor types feature straight sidebars with either standard or large-diameter rollers. Both types are precision manufactured, accurately machined and heat-treated for long service life.

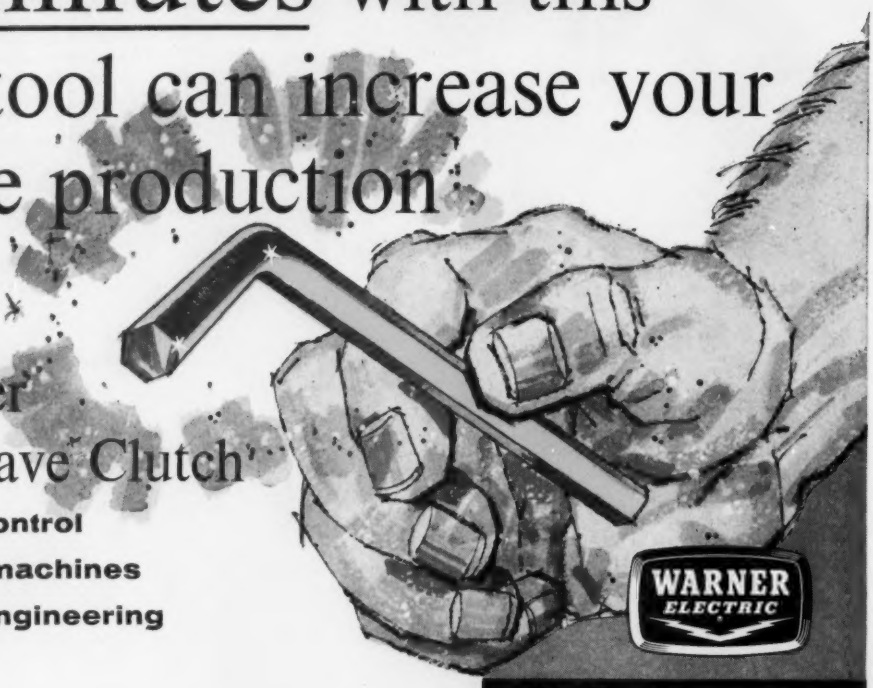
LINK-BELT

DRIVE AND CONVEYOR CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15.611

Circle 249 on Page 19

ten minutes with this simple tool can increase your machine production

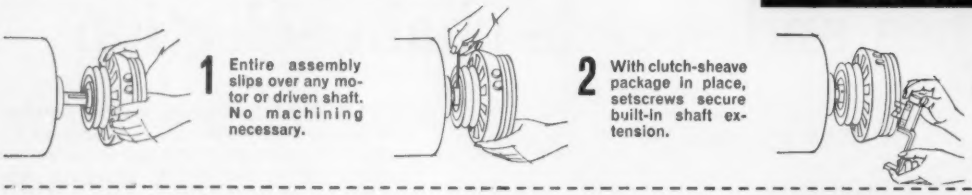


New Warner Electro-Sheave Clutch

puts automatic control on your present machines without special engineering or machining

Now you can put automatic cycling, pushbutton jogging on practically any machine — in a way that will amaze you! You begin with a familiar Allen key — and without expensive engineering, without machining or tooling of any kind — you upgrade and modernize your present machines. See what a difference automatic control can make in increased production, reduced maintenance.

In just ten minutes your Warner distributor can show you how simple it is to install an Electro-Sheave Clutch on any of your machines. Call him today — or mail coupon below.



1 Entire assembly slips over any motor or driven shaft. No machining necessary.

2 With clutch-sheave package in place, setscrews secure built-in shaft extension.

3 Mount brushholder to machine frame, wire to control. Electro-Sheave is ready!

WARNER ELECTRIC

Warner Electric Brake & Clutch Co., Dept. MD-7, Beloit, Wisconsin

I'm interested in your new Electro-Sheave Clutch.
Rush me details today.

Name_____

Title_____

Company_____

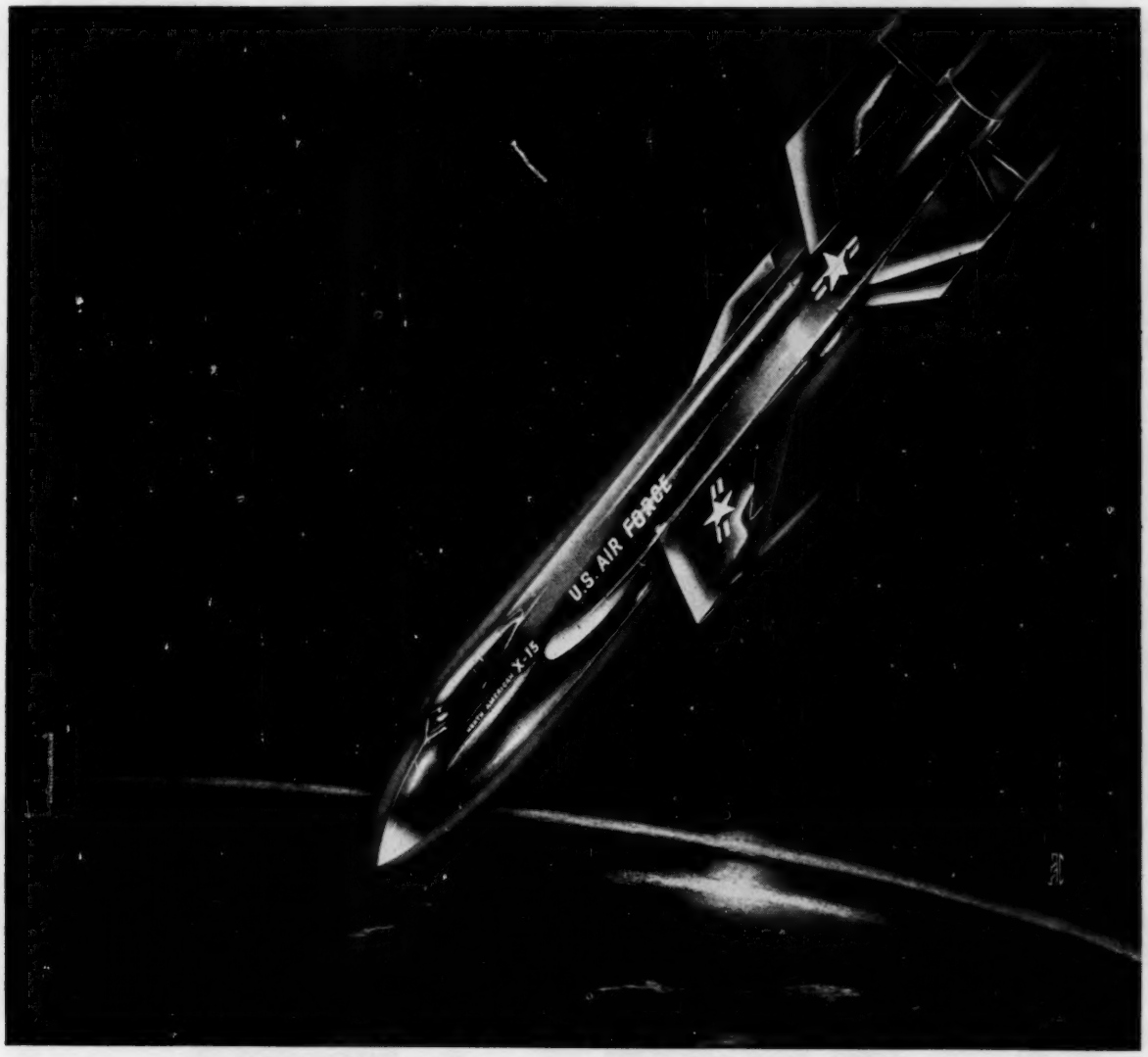
Address_____

City_____ Zone_____ State_____

This new brochure gives you all the facts!

Complete cutaway drawings, selection charts, installation details on Warner's new Electro-Sheave Clutch. Get your copy *now*.

Stocked by Distributors in Principal Cities Throughout the World



In test flight, the X-15, America's first manned space probe ship, has reached a speed of 3370 mph, and an altitude of 169,600 ft. Ship was built by North American Aviation, Inc.

How X-15 survives red-hot re-entry

When the latest pilot-controlled research rocket plane, X-15, streaks in from space to re-enter the earth's atmosphere, air friction heats its nose and leading edges to a blood red heat in seconds.

"Blood red heat" temperatures might easily weaken the skin of the X-15 ... hopelessly soften, deform or destroy many other materials.

How could designers make it possible for X-15 and her pilot to return safely?

The answer was found in an age-hardenable nickel-chromium alloy. Developed by Inco research, it successfully withstands the destructive effect of intense heat. Even when red hot, it retains the strength which the X-15 needs to safely make its re-entry into the atmosphere.

High temperature properties, corrosion resistance, strength, elasticity, beauty ... so many varied advantages can be achieved through the use of Nickel in metals.

If your business is metals, or if you use metals in your business, call on Inco for the latest information about how Nickel and its alloys can help you. *The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.*

INCO TRADE MARK **Inco Nickel**

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

REPUBLIC STEEL...

CARBON STEEL

To ASTM A-178 BOILER TUBES

STAINLESS STEEL

To ASTM A-269 CONDENSER TUBES

STAINLESS STEEL

To ASTM A-270 SANITARY TUBES

CARBON STEEL

To ASTM A-214 HEAT EXCHANGER TUBES

STAINLESS STEEL

Schedule 40S PIPE

CARBON STEEL

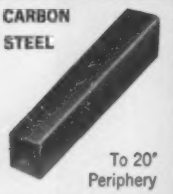
To J.I.C. Standards HYDRAULIC FLUID LINE

STAINLESS STEEL

Types 309, 309S, 310, 330 HEAT RESISTANT

CARBON STEEL

Full Range of Sizes AIR PREHEATER TUBES



CARBON STEEL

To 20" Periphery SQUARE TUBES

STAINLESS STEEL

For Exhaust Stacks AIRCRAFT TUBES

CARBON STEEL

Special Smooth I.D. CYLINDER TUBES

STAINLESS STEEL

To ASTM A-269 EVAPORATOR TUBES

CARBON STEEL

¾" Thru 6" O.D. 16 Gage and Heavier HOT-ROLLED TUBES

STAINLESS STEEL

Engineering Service SPECIAL SHAPES

STAINLESS STEEL

Beading —Punching FABRICATED TUBES

CARBON STEEL

For Corrosion METALLIZED TUBES

STAINLESS STEEL

O.D.—I.D., or Both POLISHED TUBES

CARBON STEEL

To 4"x6" Structural Grade RECTANGULAR TUBES

STAINLESS STEEL

Including 4" O.D. BRIGHT ANNEALED

CARBON STEEL

22 to 10 Gage ⅛" Thru 6" O.D. COLD ROLLED TUBES

CARBON STEEL

Also Stainless Steel GROOVED END TUBES

STAINLESS STEEL

Round, Squares, Shapes ORNAMENTAL TUBES

CARBON STEEL

Full Range of Sizes REFRIGERATION TUBES

STAINLESS STEEL

Schedule 10S—5S LIGHTWEIGHT PIPE

CARBON STEEL

To ASTM A-178 WATER WALL TUBES

STAINLESS STEEL

Combination Stainless —Carbon CLAD TUBES

STAINLESS STEEL

To ASTM A-249 HEAT EXCHANGER TUBES

CARBON STEEL

Republic Spec-101 STRUCTURAL TUBES

STAINLESS STEEL

To 5" O.D. MECHANICAL TUBE

CARBON STEEL

Technical Assistance FABRICATED TUBES

STAINLESS STEEL

Schedules 40S—10S—5S PIPE

CARBON STEEL

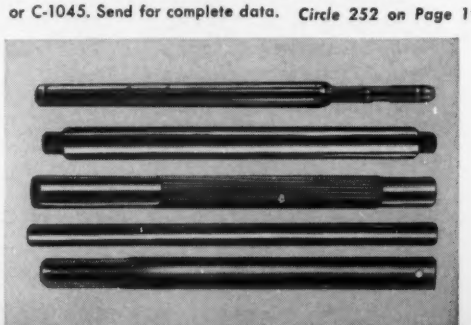
For Mechanical Use MANDREL DRAWN TUBE

Steel

Strong, Modern, Dependable

PROBLEM-SOLVING KNOW-HOW AND EXPERIENCE have made Republic a leader in custom production of Fastener and Formed Parts "Specials." Whenever standard fasteners can't do the job, you'll save time and money by contacting Republic. Write for data on Republic design, engineering, and production services. *Circle 251 on Page 19*

TRIM COLD FINISHED BAR COSTS. Republic's CENTURY SERIES offers five grades of high-strength, stress-relieved, cold finished bars, each with a minimum yield strength of 100,000 psi. For highly machined parts, use C-1144. Moderately machined parts—C-1140 or C-1151. For parts where machinability is a minor factor—C-1050 or C-1045. Send for complete data. *Circle 252 on Page 19*



World's Largest Producer of SPECIALTY WELDED TUBING

Challenge us to come up with a solution to your toughest tubing applications.

We will produce the best possible answer drawn from Republic's full line of quality welded steel tubing and more than 50 years of applied engineering experience.

This claim is made with confidence. Our customers regularly hand us their tubing problems, and the results have provided mutual satisfaction.

Manufactured at the Steel and Tubes Division, Republic Tubing is welded by the ELECTRUNITE® process—a continuous electric weld method which unites the wall under pressure without foreign or extra metal. Among other advantages, this process assures uniformity of wall thickness, strength, ductility, and concentricity.

Republic, the pioneer in this improved welding process, was also the first to provide a non-destructive electronic production method of testing tubing used for critical pressure applications. This is known to the trade as FARROWTEST®.

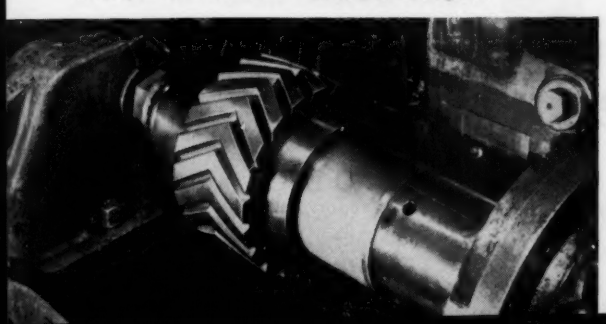
Next time you have a tubing application or problem, take advantage of Republic's prompt delivery, engineering services, and complete range of carbon and stainless steels for mechanical, structural, and pressure uses.

Call your nearest Steel and Tubes representative or contact us direct.

REPUBLIC STEEL

REPUBLIC HAS THE FEEL FOR MODERN STEEL

FOR ADDED MACHINABILITY, consider Republic Cold Drawn Leaded Alloy Steels. Leading producers of gears use Republic Leaded Alloy Steel in the manufacture of heavy-duty herringbone gears. Addition of lead increases machinability as much as 25%. Heat treating assures adequate hardness and toughness. Cost-reducing Republic Alloys are available in almost every standard analysis and many specials. Mail the coupon for information. *Circle 253 on Page 19*



Check this listing of Republic Steel Tubing and Pipe. Which have possible applications in your products?

STAINLESS STEEL

Pressure Tubing

- ☐ Condenser Tubes
- ☐ Pipe—Schedule 40S
- ☐ Sanitary Tubes
- ☐ Heat Resistant
- ☐ Evaporator Tubes
- ☐ Bright Annealed
- ☐ Pipe—Lightweight Schedule 10S—5S
- ☐ Heat Exchanger Tubes

Mechanical Tubing

- ☐ Aircraft Exhaust
- ☐ Special Shapes
- ☐ Fabricating Facilities
- ☐ Polished Tubing
- ☐ Ornamental Tubing
- ☐ Clad Tubing Carbon—Stainless

CARBON STEEL

Pressure Tubing

- ☐ Boiler Tubes
- ☐ Heat Exchanger Tubes
- ☐ Hydraulic Fluid Line
- ☐ Grooved End Tubes
- ☐ Refrigerator Tubes
- ☐ Water Wall Tubes
- ☐ Superheater Tubes
- ☐ Condenser Tubes
- ☐ Evaporator Tubes

Mechanical Tubing

- ☐ Air Preheater
- ☐ Square Tubes
- ☐ Rectangular Tubes
- ☐ Special Smooth I. D. Hydraulic Cylinder Tubes
- ☐ Hot Rolled Tubes
- ☐ Cold Rolled Tubes
- ☐ Metallized Tubes
- ☐ Structural Tubes
- ☐ Fabricating Facilities
- ☐ Drawn Tubes

Cut out and send this check list for descriptive literature on Republic Tubing and Pipe applicable to your products.

Circle 254 on Page 19

REPUBLIC STEEL CORPORATION
DEPT. MD-2158
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please also send me information on:

- ☐ Republic Cold Drawn Leaded Alloy Steels
- ☐ Republic Formed Part "Specials"
- ☐ Republic Century Series

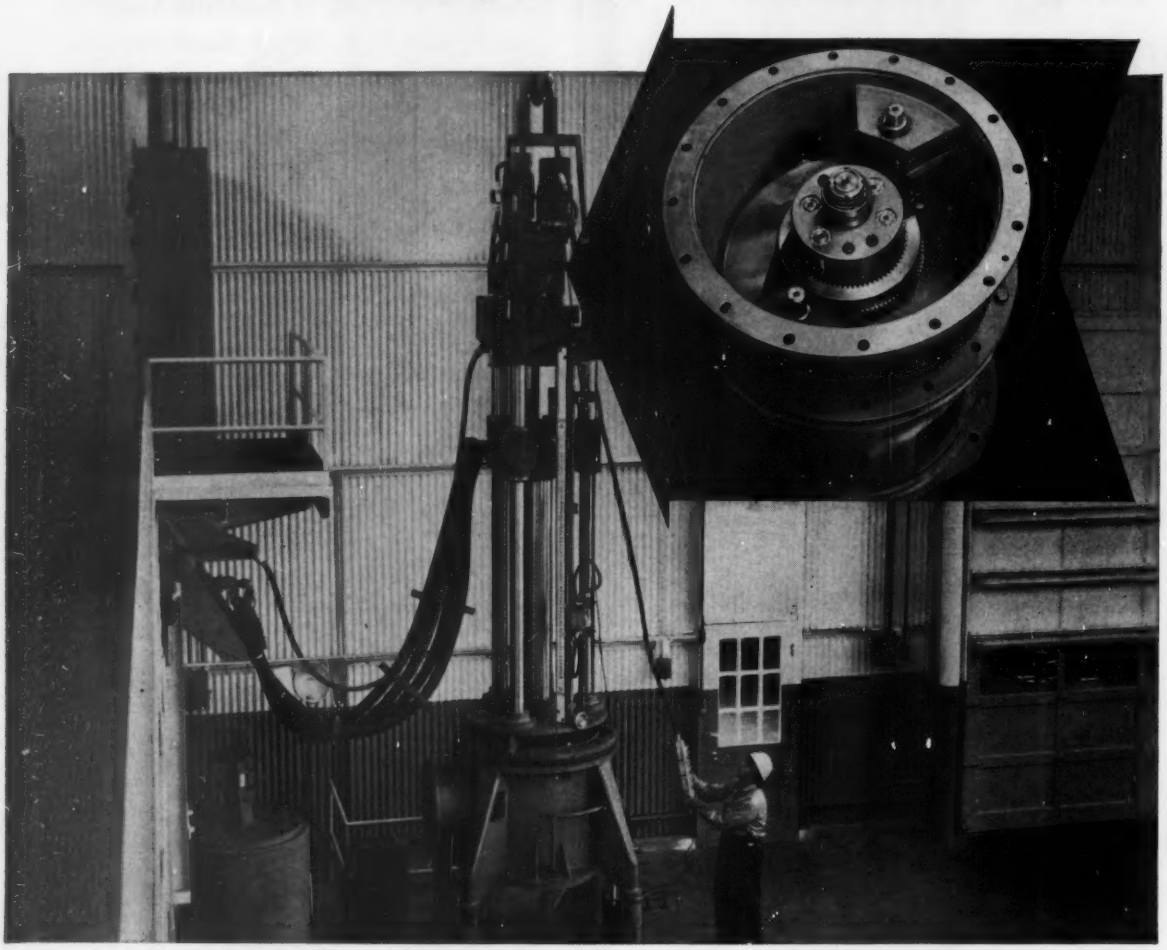
Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Philadelphia Precision Ground Gearing Increases Sensitivity of New Vacuum Arc Furnace



Philadelphia precision ground gearing is responsible for smoother, more efficient operation of a new consumable electrode vacuum arc melting furnace installed at Standard Steel Works Division of Baldwin-Lima-Hamilton Corporation.

This specially designed differential reduction, planetary gear drive greatly increased the efficiency of the furnace. The old problem of stop-start action with uneven electrode burnoff has been completely eliminated. Now, uniform electrode feed permits arc voltage to be maintained within ±.1 Volt. Electrode burnoff is uniform.

This drive problem is typical of hundreds that have been solved with Philadelphia hardened, precision ground gearing . . . problems where improved gear accuracies have resulted in space and weight savings, higher-speed operation, reduced sound and vibration levels, and longer gear life—all at no increase in cost.

Our experienced engineering staff, specialists in all types of power transmission problems, make sure that proper design and materials combine to meet your most exacting needs.

For more complete information, write on your company letterhead for our Catalog: AN ADVANCED CONCEPT IN MODERN GEARS.

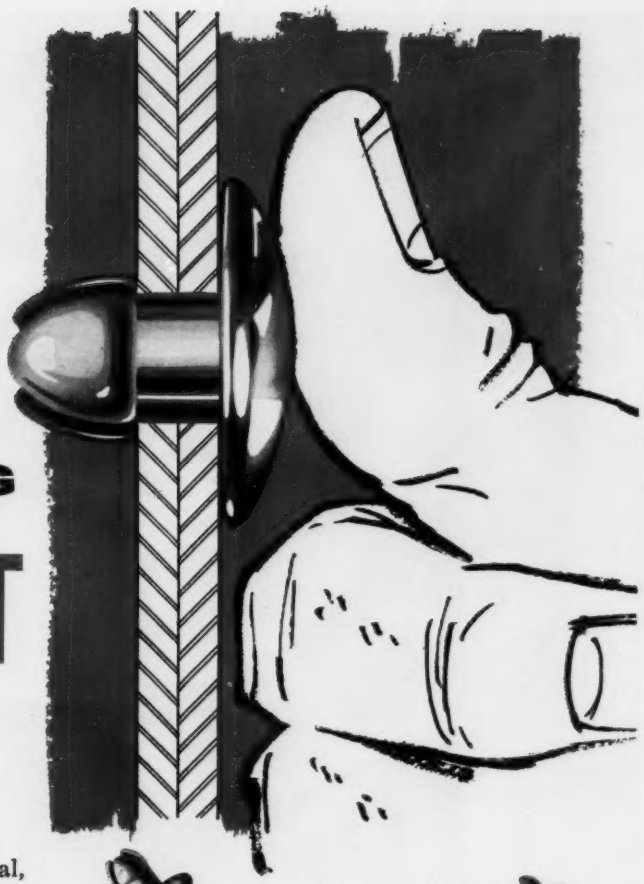
philadelphia gear drives

PHILADELPHIA GEAR CORPORATION

King of Prussia (Suburban Philadelphia), Pennsylvania

Circle 277 on Page 19

to fasten
panels
or parts . . .



LIGHT, STRONG

TRIMOUNT STUDS

Designed for rapid assembly of sheet-metal, plastic or composite structures, Dot Trimount studs are available in both permanent and removable types. They can be pushed into drilled, stamped or molded holes by finger-pressure alone yet they lock positively in place and resist constant vibration.

Studs can be designed in steel or brass with various flange configurations for clinch, clip or clamp attachment to flexible or rigid panels as well as for push-through assembly. Available in all standard finishes . . . with or without decorative caps.

Push Rivet Stud Shoulder Type (Capped)
Push Rivet Stud Tapered Type (Capped)
Push Rivet Stud Shoulder Type (Not Capped)
Push Rivet Stud Tapered Type (Not Capped)
Clinch Type Stud
Clip-on Stud
Trim Stud Barrel Type
Trim Stud Scissors Type
Panel Type Stud
Loop Type Stud
Panel Stud Staple Type
Panel Stud Hook-on Type

DESIGN ENGINEERING SERVICE

Designers, metallurgists and plastics specialists on Dot's engineering staff are equipped to work out optimum combinations of metal and plastics to suit your particular requirements.

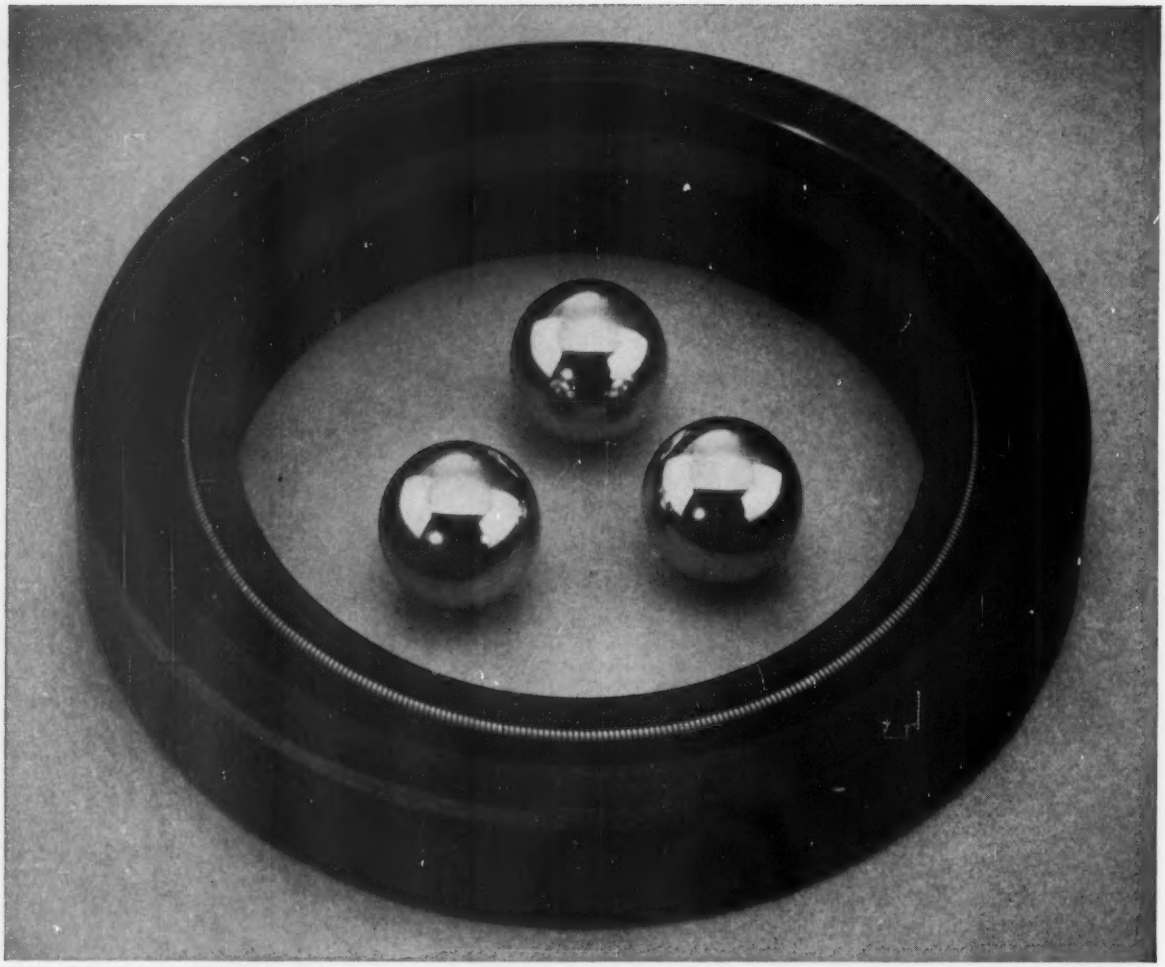
▶ *For further details, write for Engineering Data Catalog, Section H*

MAKERS OF DOT FASTENERS

CARR FASTENER COMPANY

Division of United-Carr Fastener Corporation, Cambridge 42, Mass.

Offices in: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, San Francisco, Seattle, Syracuse



Learn why J-M Clipper® Seals give you better protection for bearings

J-M Clipper Seals protect better because each is specially compounded to do its specific job. When you install the *right* Clipper Seal for your service conditions, it keeps lubricant in, seals out damaging dirt and grit . . . resists heat, speed and corrosive chemicals . . . gives you long, efficient protection. Here are the reasons why you can count on Clipper Seals for better service:

DUAL-COMPOUND CONSTRUCTION. A Clipper Seal consists of a soft, flexible lip and a tough, dense asbestos-compound heel, concentrically molded into one unit. There's nothing in a Clipper Seal that can rust, corrode or cause pitting of bore surfaces. In styles using a garter ring, even the spring is made of stainless steel.

DESIGN. J-M offers many design cross-sections to assure better protection and efficient sealing between regular overhauls.

SPECIAL MATERIALS. J-M will precision-mold Clipper Seals from materials that best suit your requirements. J-M is equipped to work with many materials: elastomers, including Du Pont Teflon . . . neoprene . . . silicones . . . and fluorinated, polyacrylic or other rubbers.

EASY INSTALLATION. Clipper Seals come away clean and easy. Replacement is fast, and requires no special tools or adhesives. You'll never have to scrape or refinish bore surfaces, because the compound heel protects the bore from damage. For quick, temporary replacement, Johns-Manville produces a special split seal.

SELECTION. Your J-M Distributor is a seal specialist. Just tell him your service conditions, and he will help you make exactly the right selection from J-M's wide range of designs, compounds and durometer stocks.

For complete information, see your J-M Distributor. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, address Port Credit, Ont.

JOHNS-MANVILLE
CLIPPER SEALS

JOHNS-MANVILLE JM PRODUCTS

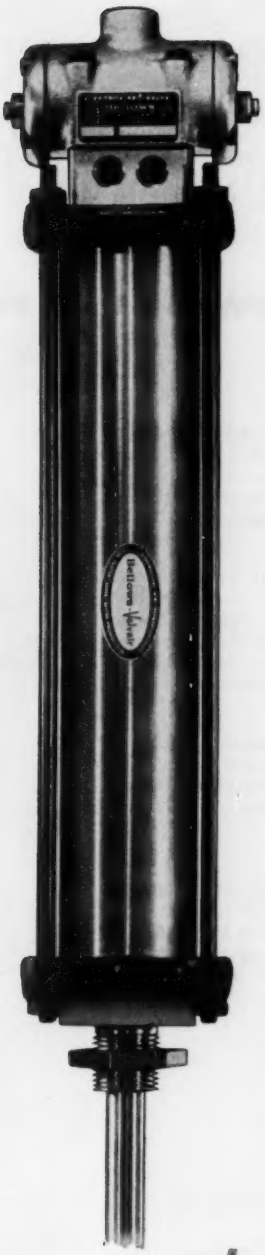
Circle 255 on Page 19

Design with Air in Mind

The range of control systems available with the Bellows Air Motor® (the air cylinder with the built-in valve) gives the engineer a flexibility in design that not only lessens his work but enables him to build his machine at lower cost. Not only to build it at lower cost but to build it to perform more efficiently and at lower cost to the user.

Wherever a push, pull, lift or turn motion is performed by mechanical means, such as cams, gears, levers or linkages, you'll save all the way down the line—**by designing with air in mind.**

One of the more than 200 trained Bellows-Valvair Field Engineers will be happy to work with you in applying economical air power to your specific projects. Write today to Dept. MD-761 for Bulletins BM-25 and FP-60.



Bellows-Valvair

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

1104-C

Circle 256 on Page 19

Engineering Data

WINSMITH SPEED REDUCERS

HOLLOW SHAFT WORM GEAR SPEED REDUCERS

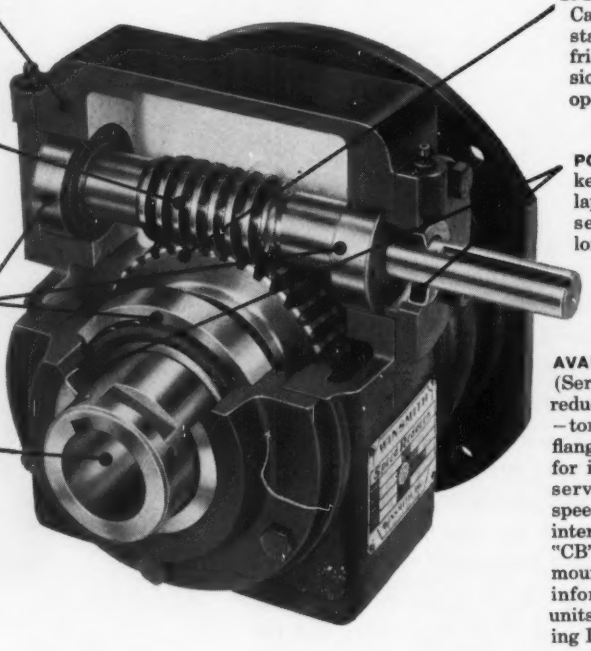
single and double reduction . . . torque arm and flange mounted models

CAST IRON HOUSINGS designed for high heat radiation. One-piece construction, close-grained gray iron for maximum strength and rigidity.

CASE-HARDENED STEEL WORMS cut integral with the shaft. Heat treated for close-grained tough core, carburized and hardened before grinding. Meet AGMA long-wear specifications.

TAPERED ROLLER BEARINGS for minimum maintenance, long bearing life and permanent shaft alignment. High radial and thrust load capacity.

HOLLOW SLOW SPEED SHAFTS in wide range of standard bore sizes and keyways. Mounts on shaft of driven machine *without bushings*—two external slots facilitate removal with standard wheel puller.



SPECIAL BRONZE WORM GEARS Cast to recommended AGMA standards. Low coefficients of friction and thermal expansion for cooler, more efficient operation.

POSITIVE OIL SEALS keep oil in, dirt out. Shafts lapped to micro-finish under seals for uniform contact. longer seal life.

AVAILABLE in single reduction (Series ST and SF) and double reduction (Series STD and SFD) —torque arm ("T" models) and flange mounted ("F" models)— for intermittent or continuous service. Hollow shaft slow speed assembly of "ST" series interchangeable with Winsmith "CB" and "CT" Series with foot mounted housings. For further information on these latter units, write Winsmith Engineering Department.

- *12 Models*
- *.041 to 8.82 H.P.*
- *Ratios 7½:1 to 4466:1*
- *Max. Output Torque 816 to 7678 in. lbs.*

Winsmith Hollow Shaft Speed Reducers cover a broad range of power transmission requirements for both single and double reduction drives. *Their worm gearing provides much higher reduction ratios than are possible in comparable size units using other types of gearing.* Winsmith Hollow Shaft models are designed for all applications where it is advantageous to mount the reducer on the shaft of the driven machine. They are compact, easy to install and require less space than conventional units. Their design and construction provide high shock load resistance; maximum thermal capacity without induced cooling; greater overhung capacity; and a high degree of standardization which eliminates excessive special application engineering.

Write today for complete information or call your nearest Winsmith Representative listed in the Yellow Pages. He is a technically trained expert who is always ready to help you with any speed reducer problem. For both standard and special power transmission applications, you'll find it pays to standardize on Winsmith.

WINSMITH, INC.

202 Eaton Street, Springville, (Erie County), New York

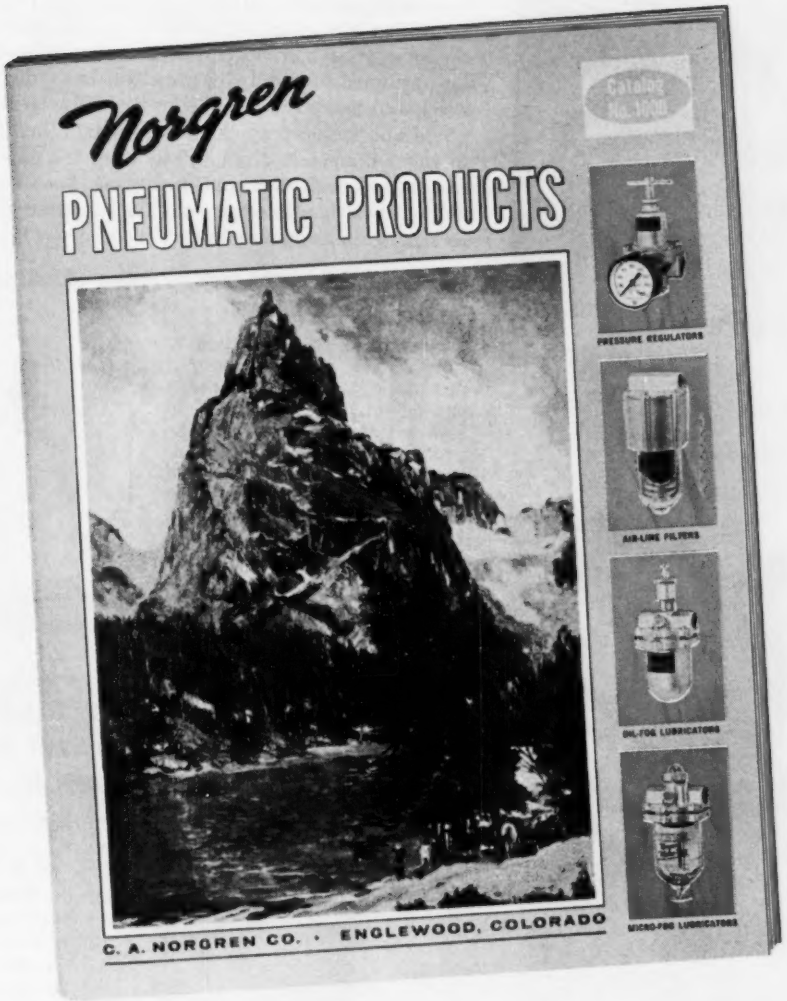
MEMBER OF AGMA

• • • Winsmith Speed Reducers are made by American craftsmen to meet American design and production standards.

If you use or design for compressed air

...and don't have this new catalog...

be sure to send for it *today!*



Please fill out this coupon or write on your company letterhead

FOUNDED IN 1926

C.A.NORGREN CO.

3442 SOUTH ELATI STREET
ENGLEWOOD, COLORADO

To: C. A. NORGREN Co., 3442 So. Elati St., Englewood, Colo.

Gentlemen: Please send me without cost or obligation your new catalog, No. 1000, on the complete Norgren line of pneumatic products.

Name_____
(Please print)

Title_____

Company Name_____

Company Address_____

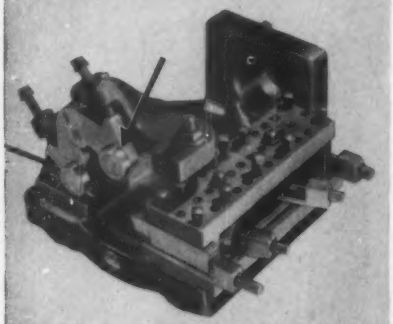
Circle 258 on Page 19

McGILL® CAMROL® BEARINGS

are proven performers—with cost and assembly advantages

McGILL CAMROL bearings have rolled up an unequalled 25-year history of high performance and dependability — with the cost savings of standard bearings over built up shaft and roller units. They eliminate the time-consuming intricacies of procurement and assembly of parts for improvised bolt, bearing and washer followers. You, too, can rely on the designed-in ability of CAMROL bearings to accept intermittent shock and fluctuating heavy loading coincident to cam action, track or guide and support applications. CAMROL bearings are built for stock in roller diameters from ½" to 4" in the CF series with integral stud and the CYR series for shaft mounting. Both types are available with or without positive, integral seals for retention of prelubrication and protection against contaminants. Following are typical applications.

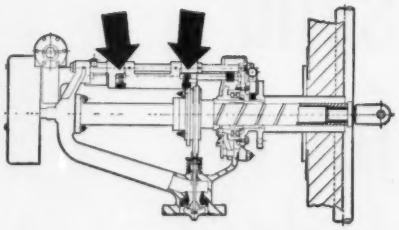
GISHOLT MACHINE COMPANY incorporates McGILL CAMROL® bearing accuracy into tooling set-ups

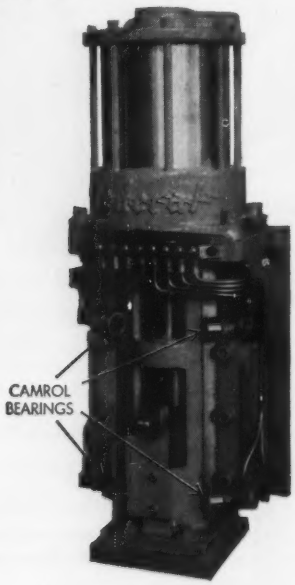


Gisholt Machine Company takes advantage of the cost and performance features of CAMROL CF series bearings, (with integral stud), on a group of standard bar tools for mounting on the turrets of Gisholt Masterline Turret Lathes. A representative tool of this group is the Multiple Cutter Turner shown.

CF CAMROL® bearings provide rolling contact in automatic soot blowers

Diamond Power Specialty Corporation has incorporated McGILL CAMROL bearings into the design of their Model IR Short Retraction blowers to produce a smooth rolling contact between cam flange and latch bar. This equipment is used for cleaning water cooled furnace walls, hopper slopes or narrow portions of tube banks adjacent to walls automatically.





FEDERAL MACHINE and WELDER COMPANY puts McGILL uniform quality into welding equipment

The anti-friction welder head unit, shown, is one of the several applications of McGILL CF CAMROL bearings in Federal Machine and Welder Co. equipment. CAMROL bearings are used in weld heads, transfer slides and various other uses where a precision, smooth, uniform movement is desired. Low cost, uniform quality, excellent performance and exceptional length of life are benefits gained in eleven years of use of CAMROL bearings.

Both the regular CF Series and the prelubricated and sealed SCF Series CAMROL bearings are used in Federal equipment.

engineered electrical products

McGILL®

precision needle roller bearings

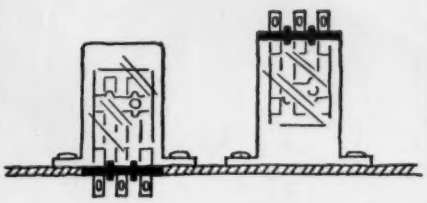
Send for free copy of McGILL Bearing Catalog No. 52-A.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

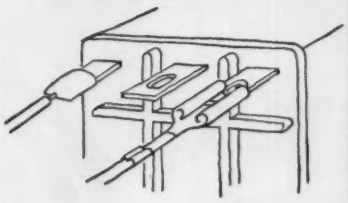
McGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette Street, Valparaiso, Indiana

Circle 259 on Page 19

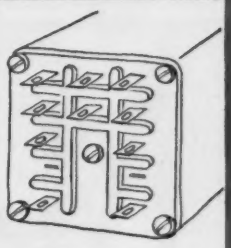
FRESH IDEAS IN RELAYS...



CHOICE of below-chassis or above-chassis connecting in plastic enclosures.



MULTI-USE terminals allow soldering, insertion in printed circuit board, and use of AMP Style 110 push-on terminals.



ALL TERMINALS on *one* panel... permits insertion in printed circuit board.

SPECIFICATIONS

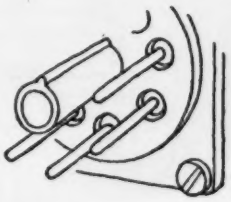
CONTACTS: *Integral with terminals;* up to 3PDT; 5 amp, 115 VAC or 32 VDC. Stationary contacts, fine silver inlay material; movable, solid fine silver.

COILS: Up to 230 VAC at 60 cps or 115 VDC.

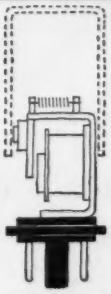
ENCLOSURES: Clear plastic.

TERMINAL PANELS: Barrier type or octal plug.

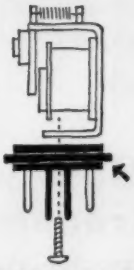
LATCHING RELAY: Available enclosed in clear plastic with plug-in mounting; or unenclosed.



OCTAL PLUG relays up to DPDT have recessed pin bases . . . meet UL spacing requirements to 150 V.



ALL ENCLOSED relays mount solidly on base . . . *not* on covers.



INTEGRAL plug-in base up to DPDT avoids wiring between contact terminals and pins.

OHMITE'S New "GR" Series

Stocked for Immediate Delivery From Distributors or Factory...

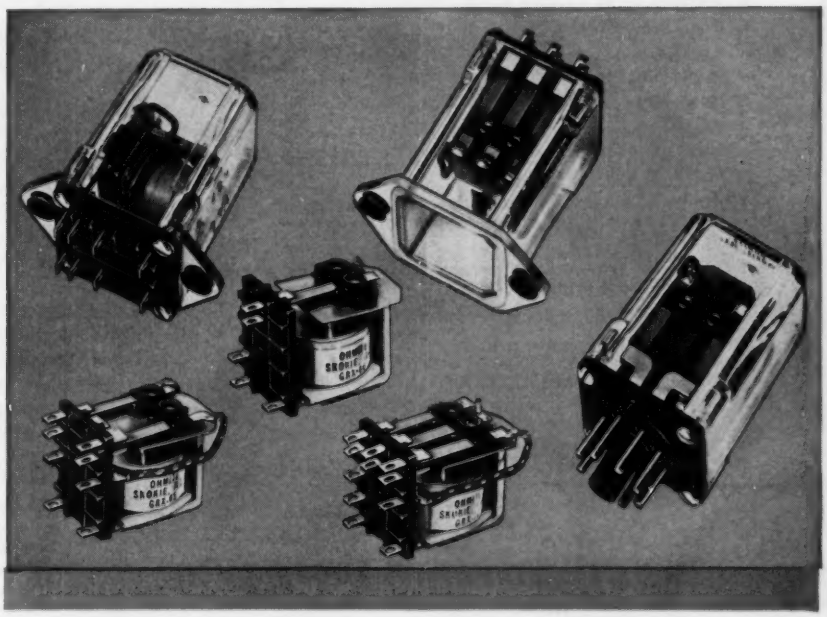
WRITE FOR BULLETIN 166

OHMITE

OHMITE MANUFACTURING COMPANY

3618 Howard Street
Skokie, Illinois

Rheostats • Power Resistors
Precision Resistors
Variable Transformers
Tantalum Capacitors • Tap Switches
Micromodules • Relays
R.F. Chokes • Germanium Diodes



New

ROTO MISSION®

PATENTED

Most versatile transmission ever developed!

ONLY ROTO-MISSION GIVES YOU ALL THESE FEATURES

- Concentric configuration
- Minimum size for a specified torque
- Reduction ratios up to 270:1
- Optional torque capacities for each reduction ratio
- Torques up to 21,850 lb.-ft.
- Requires neither driving pulley nor coupling
- Casehardened helical gears—ground after hardening for perfect engagement
- Reversible
- Progressive overload capacity to the extent that no breakage of gears can result even from the severest abuse
- *Ability to engage or disengage driving action —mechanically, pneumatically, hydraulically or electrically
- *Ability to provide load releasing, load limiting or overload alarm
- *Ability to provide 2-speed operation

*Standardized accessories to provide these features are available for all sizes of Roto-Mission from stock. This results in a single responsibility for installation performance.

This new rotary transmission design combines a wide range of reduction ratios, high torque capacities, and excellent space-saving characteristics to give you more application versatility than ever before possible. It is designed to be concentrically mounted on a machine drive shaft in place of the drive pulley and operate this shaft at a reduced speed from that of the driving motor. For maximum compactness and convenience, all its parts are inside the casing.

The standard accessories available for each model of Roto-Mission add even greater versatility. Through them you have systems—from a single source—capable of control functions that previously required a number of unmatched units from several suppliers.

Because of its versatility and sound engineering, Roto-Mission permits you to solve design problems far beyond the range of other transmissions —may even permit incorporation of features in your machines that have not previously been possible. For complete information on this new product—how it operates and how it can help you —write today for catalog IR-61.

AIRBORNE®

Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY • Offices in Los Angeles and Dallas

MOTORS

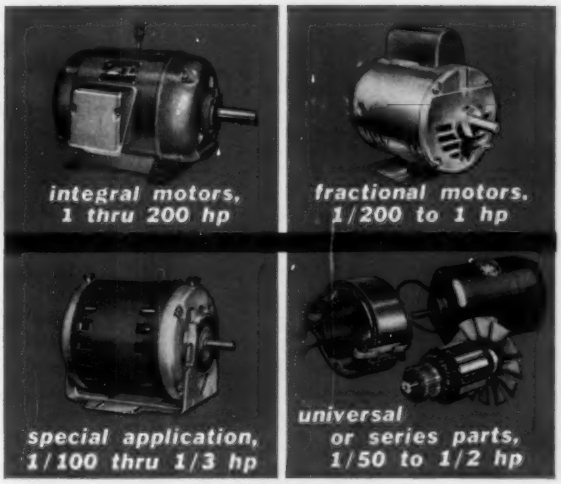
1/200 thru 200 HP

from machine tools to typewriters . . .

. . . Robbins & Myers motors power them all!

Each R&M motor, 1/200 through 200 HP, is electrically and mechanically designed with life-prolonging features which assure dependable operation, simplified installation and low maintenance. From rugged machine tools to complex business machines, there's an R&M motor for every job . . . Fractional and Integral H.P. Motors and Motor Parts in all popular mountings, electrical types and enclosures. Most are ready for off-the-shelf delivery. Others can be quickly produced. Should you require custom motors, R&M's experienced application engineers, aided by modern electronic computers, can furnish the one design best suited to your needs.

Write today for information, or send your powering problem to R&M. No obligation, of course!

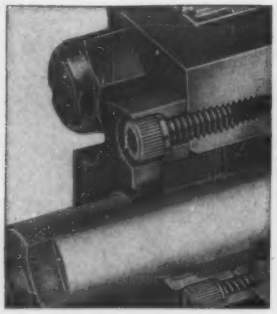


ROBBINS & MYERS, INC., Springfield, Ohio

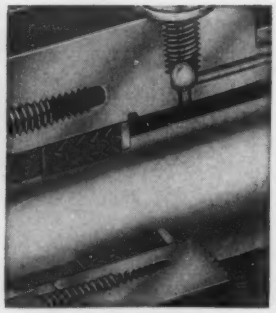
Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

Circle 262 on Page 19

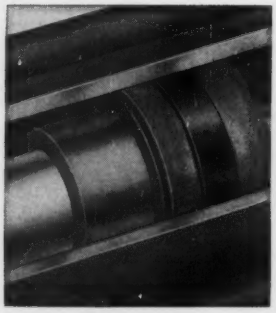
Do the cylinders you buy include these quality features?



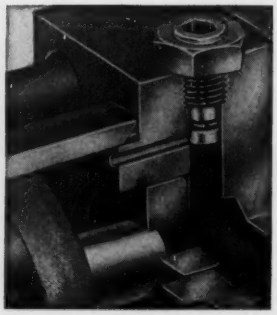
ROD GLAND—Easily removed. No need to loosen tie rods. Cuts maintenance time in half. Phenolic bearing insert will not score rod. Cuts replacement cost to a minimum.



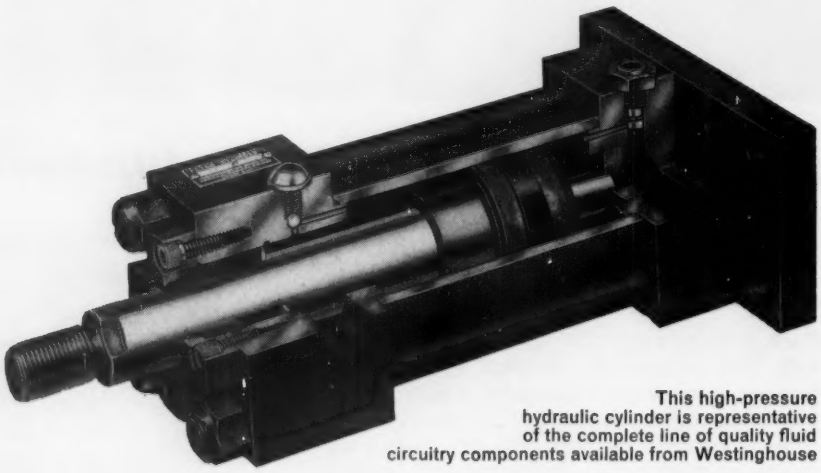
ROD PACKING—Interlocking multiple lip seals require no adjustments; remain flexible under fluid pressure. Wear compensating function eliminates frequent replacement.



PISTON—Phenolic piston will not score tube. Packing cups used for proven long life and seal. Cups are easily replaced. Piston positively locked to rod.



CUSHION—Minimum clearance between piston and Meehanite Bushing combined with micrometer metering gives top cushioning efficiency and a wide adjusting range.



This high-pressure hydraulic cylinder is representative of the complete line of quality fluid circuitry components available from Westinghouse

if not, the chances are, your maintenance costs are higher than necessary. For more information about Quality Fluid Circuitry Controls for trouble-free automation, ask for Catalog A3-56.00.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

Circle 263 on Page 19

Lamb Electric's "Clean Room" insures fractional horsepower motor perfection

For assembly of small precision gear motors, Lamb® Electric has installed an air-conditioned, dust-free "Clean Room". This innovation, primarily for the assembly of these custom-built motors, is essential for eliminating even particles of dust.

The "Clean Room" is typical of progressive Lamb thinking that insures perfection in fractional horsepower motor design and manufacture.

Do you have a special motor problem? . . . Here's what you can expect from Lamb! *Into the design* of a Lamb motor goes years of experience in powering components for aircraft, domestic and industrial products. *Out of the design* comes a personalized motor that's dependable, smooth and efficient.

Cost-wise you're way ahead, because Lamb Motors are mass-produced at the most favorable cost.

Write today for descriptive folder. Or ask to have a District Engineer call and set up a personalized "Motor Conference".

THE LAMB ELECTRIC COMPANY · Kent, Ohio

A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric—Division of Sangamo Company, Ltd.
Leaside, Ontario

Circle 264 on Page 19

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Divisions of American Machine and Metals, Inc., New York 7, New York TROY LAUNDRY MACHINERY
RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS
NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC CO. • HUNTER SPRING CO. • GLASER-STEERS CORP.

in at top...out at bottom

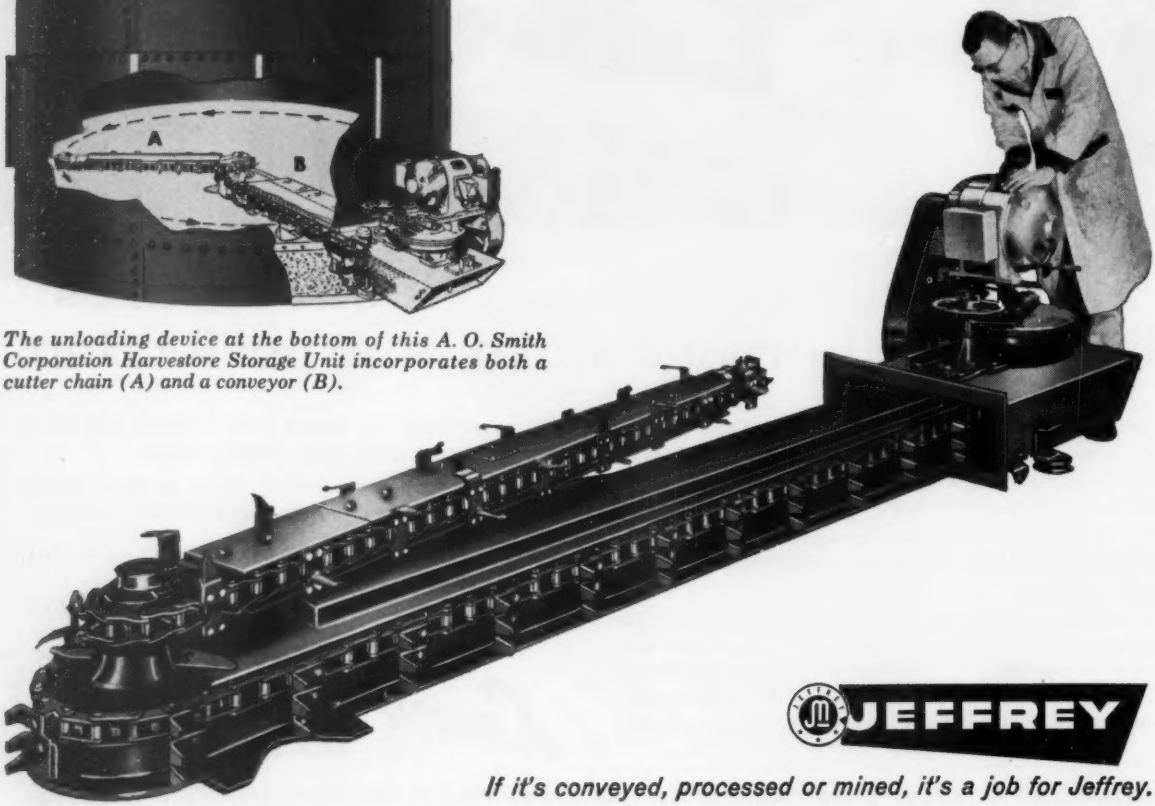
Sweep-arm unloader mechanizes Harvestore materials storage

This mechanical bottom unloader provides an efficient means for feeding out tons of free-flowing bulk material—even though additional tons of farm or industrial materials may be loaded on top. As the sweep-arm passes around the bottom of the unit, cutters attached to its chain loosen tightly packed material and move it to the center. There it drops to another subfloor chain conveyor and is carried outside.

Two types of Jeffrey chain contribute to the dependable performance of the Harvestore Unit. STR chain on the sweep arm has special attachments on which cutters are mounted. Both the cutter chain and the Jeffrey Combination Chain used on the conveyor are unusual, in that they operate on their side, thereby requiring a quality product.

Jeffrey chain is designed for hard service—built for rugged going—whether employed for power transmission, conveying or digging. For engineering assistance in applying Jeffrey chain to your equipment, write The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

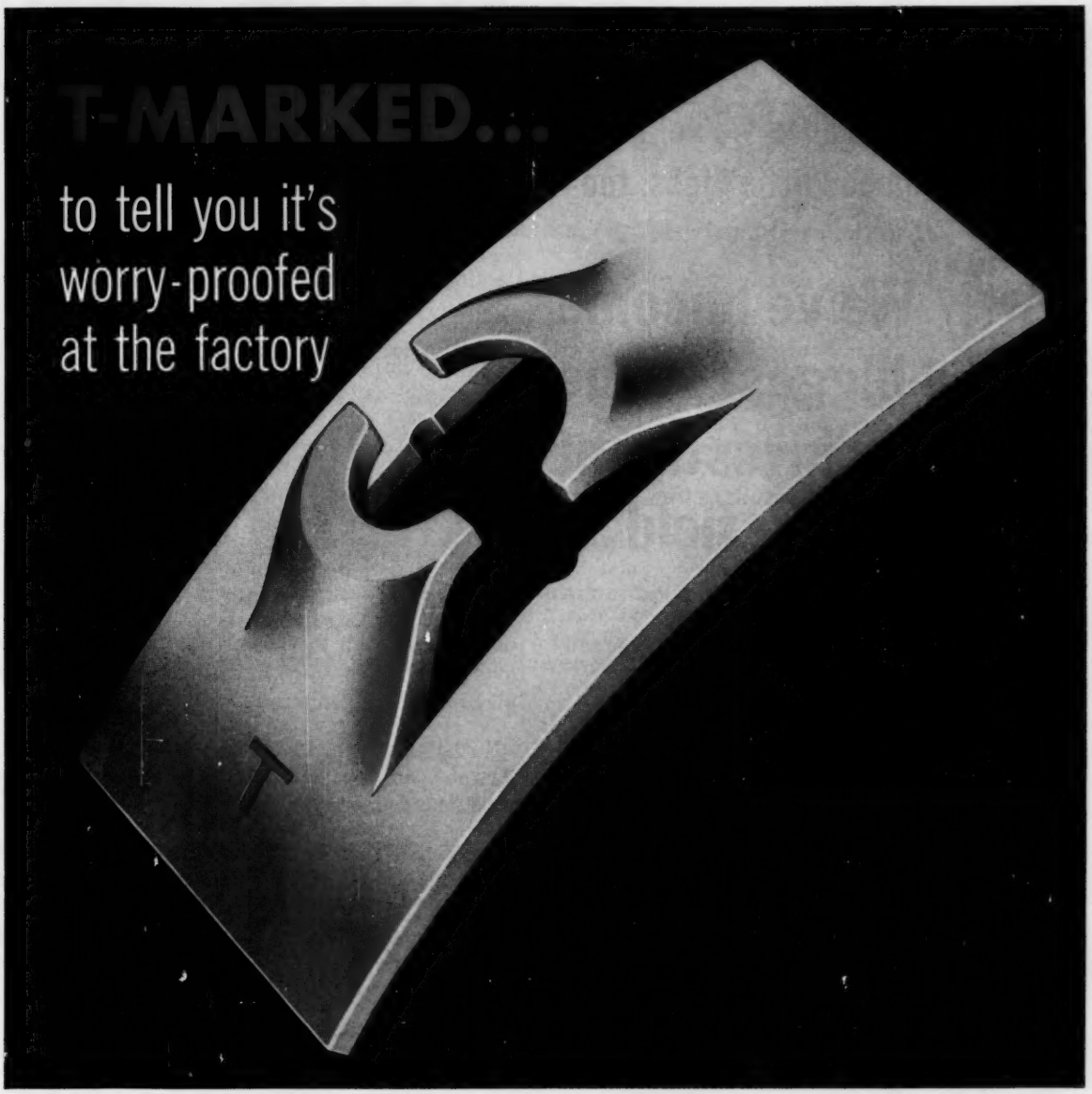
The unloading device at the bottom of this A. O. Smith Corporation Harvestore Storage Unit incorporates both a cutter chain (A) and a conveyor (B).



JEFFREY

If it's conveyed, processed or mined, it's a job for Jeffrey.

Circle 265 on Page 19



Other spring fasteners may look like Tinnerman SPEED NUTS. But only the *T-marked* ones really are SPEED NUTS . . . really are "Tinnermans". . . made to highest quality and precision standards to assure worry-proof performance on your assembly.

Here's what the exclusive Tinnerman T-mark means to fastener users:

Over thirty-five years of Tinnerman experience as the originator and largest producer of spring-steel fasteners...the leader in solving your fastening problems,

Outstanding fastener design and production experience that assures you the best possible design of SPEED NUT, whether it is a special SPEED NUT or one of the 10,000 SPEED NUT brand fasteners presently available,

Stringent control of SPEED NUT quality from coil strip to you, including die design, production, heat treatment and finishing.

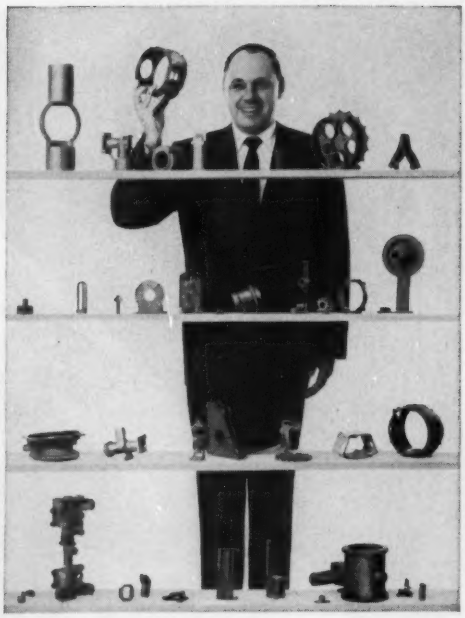
Be sure you specify "Tinnerman T-marked SPEED NUTS" that give you better fastening, that cut parts and assembly costs, that never let you or your customer down. *Tinnerman Products, Inc., Dept. 12, Box 6688, Cleveland 1, Ohio.*

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario.
GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales.
FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Suresnes (Seine).
GERMANY: Mecano Simmonds GMBH, Heidelberg.

TINNERMAN
Speed Nuts®
Look for the Tinnerman "T"

Because we've always welcomed "little" jobs, too–

We've become the biggest in the investment casting field...



No investment casting job has ever been or ever will be too small for us.

WE DON'T HAVE ANY "SIDELINES," nor is investment casting only a sideline with us. It is the "be-all and end-all" of our economic existence.

AS A RESULT: anybody who thinks that an investment casting will help him solve a problem gets the unqualified attention of the top talent we have to offer–from our trained field engineers, our design engineers, our estimating staff, our tooling men, and our production specialists. No one of these groups cares whether your order is for 50 parts or 100,000. If they accept the order, they want it handled to or above "specs".

WHY? SIMPLY BECAUSE THESE MEN ARE DEDICATED to producing the finest that the process can deliver in any design, in any castable alloy and in quantities so small that it might surprise you.

THEIR ATTITUDE IS FAR FROM PHILANTHROPIC; they realize full well that your "little ones" may soon grow up.

ARWOOD IS READY WHEN THEY DO ... more so than any other investment caster. In fact, we can take in stride all the volume that's required. Our five plants, each fully integrated, can handle the biggest job you can offer.

ONCE THE PROTOTYPE PHASE IS COMPLETED, Arwood can give you the quantity production you need, and deliver it when you need it.

WHAT MORE CAN WE SAY? Simply this. Most "difficult" components, no matter what the alloy or quantity, might well be produced as an Arwood investment casting ... and THE COST IS OFTEN EXTREMELY LOW, compared with conventional methods.

ON THE OTHER HAND, IF WE CAN'T DO IT–and do it economically–we'll be the first to tell you so immediately. We'd rather lose an order than a customer. Try us and see.

ARE YOU REALLY UP-TO-DATE ON WHAT INVESTMENT CASTING CAN DO? Our 48-page "Practical Guide" gives forthright answers... tells how to design for the process, gives complete tables on properties. It's yours for the asking.

Machine the simple ... cast the complex

A complete service from design through tooling, production and finish machining. Seventy-one engineering representatives from coast to coast.

arwood

ARWOOD CORPORATION • **315 West 44th Street, New York 36, New York**

PLANTS IN BROOKLYN, N. Y.; TILTON, N. H.; GROTON, CONN.; LOS ANGELES AND LA VERNE, CALIF.

WHY RISK LOSS OF GEAR SHAPER PERFORMANCE?

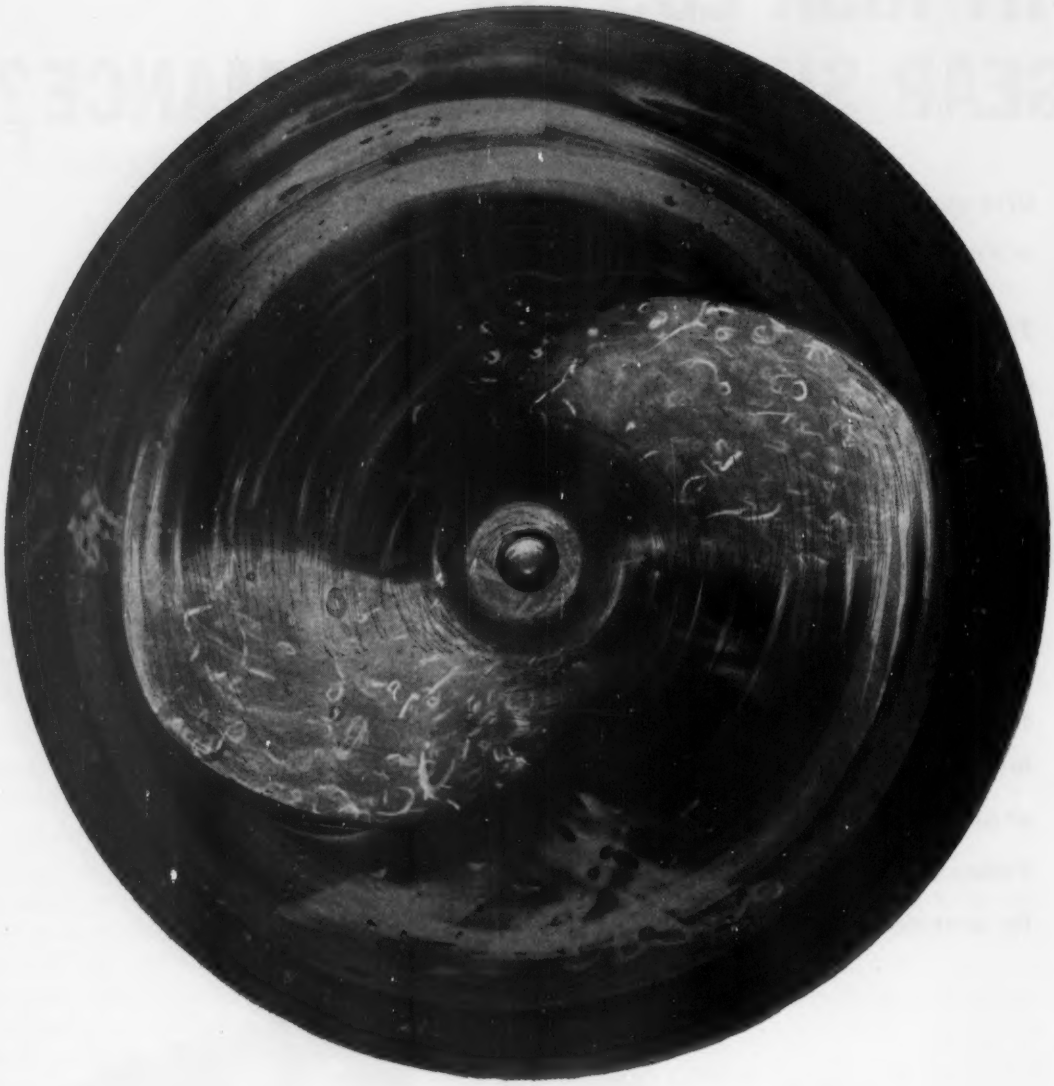
Give your products all the high-production, high precision advantages of Fellows Gear Shaper performance by tooling up with Fellows cutters.

The better design of Fellows cutters is the result of advanced engineering techniques, including the use of a high-speed computer for solving design and application problems. Their better quality is the result of constant advances in metallurgy and manufacturing methods. And, proof of their better performance are the thousands of Fellows cutters in use on modern gear production lines.

Fellows cutters on Fellows machines lower costs and speed production on external and internal, spur and helical involute gears and a wide variety of non-involute shapes as well. All Fellows Offices are at your service for providing information.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont, U.S.A.
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE **Fellows** *Gear Production Equipment*



Mr. Design Engineer:
Is high torque strength of interest to you?

Take a look at the reinforced Plaskon® Nylon specified by a prominent manufacturer for their newest outboard propeller. The material is Nylafil G-3 — Plaskon Nylon reinforced with glass fibers under carefully controlled conditions by the Fiberfil Corporation, Warsaw, Indiana.

They chose this material because of its outstanding tensile and flexural strength which enables it to meet the high torque requirements of an outboard propeller. Also important are its excellent resistance to corrosion and electrolysis, outstanding impact resistance, light weight, improved dimensional stability, and fine resistance to abrasion (propellers are tested by running over sand bars and oyster beds).

Even if your field isn't marine engineering, these properties should be of interest to your particular design problem. Let our Applications Engineering Group work with you — write our Nylon Design Department.

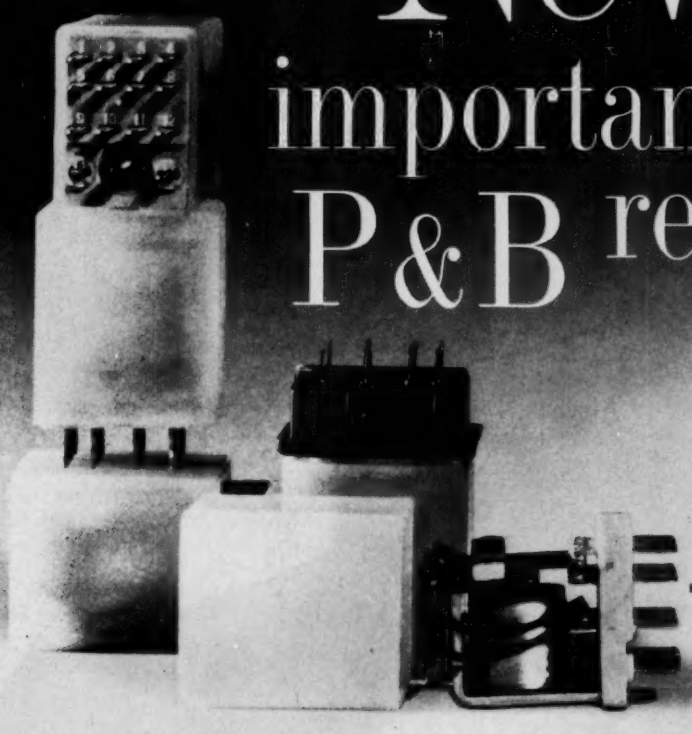
PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical
BASIC TO AMERICA'S PROGRESS

Circle 269 on Page 19

Circle 270 on Page 19→

a New and important P&B relay . . .

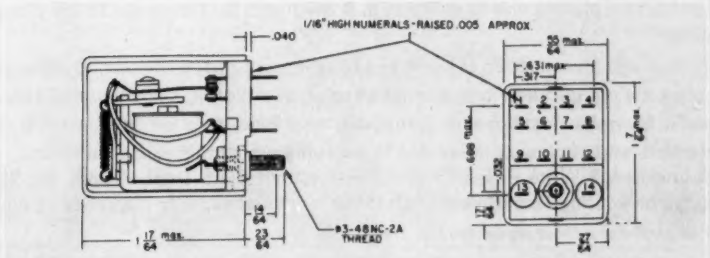


KHP SERIES SHOWN ACTUAL SIZE

having rare longevity

This small, 4-pole relay has the happy faculty of maintaining its original operating tolerances over an exceptionally long life. Example: tests (by customers!) show this relay has variations in electrical characteristics of less than 5% after more than 100 million operations.

But that's far from all. This is a *small* relay . . . about a one inch cube. This relay is easy to install using the conveniently spaced solder lugs or a socket. Thus you save time and production costs. This relay is versatile . . . its 4PDT contacts will switch loads from dry circuit up to 3 amperes. This relay—well, why not order samples and see for yourself! Order today from your P&B representative or call us at Fulton 5-5251, in Princeton, Indiana.



KHP SERIES SPECIFICATIONS

CONTACTS:

Arrangement: 4 Form C, 2 Form Z.

Material: ⅛" dia. Silver standard. Silver cadmium oxide and gold alloy available.

Rating: 3 amps @ 30 volts DC or 115 volts AC resistive for 100,000 operations.

COILS:

Resistance: 11,000 ohms max.

Temperature: Operating Ambient: —45°C. to +70°C.

Power: 0.5 watts min operate @ 25°C. 0.9 watts nom. @ 25°C. 2.0 watts max. @ 25°C.

TIMING VALUES:

Nominal Voltage @ 25°C.	Max. Values
Pull-in time	15 ms
Drop-out time	5 ms

INSULATION RESISTANCE: 1500 megohms min.

DIELECTRIC STRENGTH:
500 Volts RMS 60 cycles between contacts.
1000 Volts RMS 60 cycles between other elements.

MECH. LIFE: In excess of 100 million cycles.

SOCKET: Solder lug or printed circuit terminals. Available as accessory.

DUST COVER: Standard.

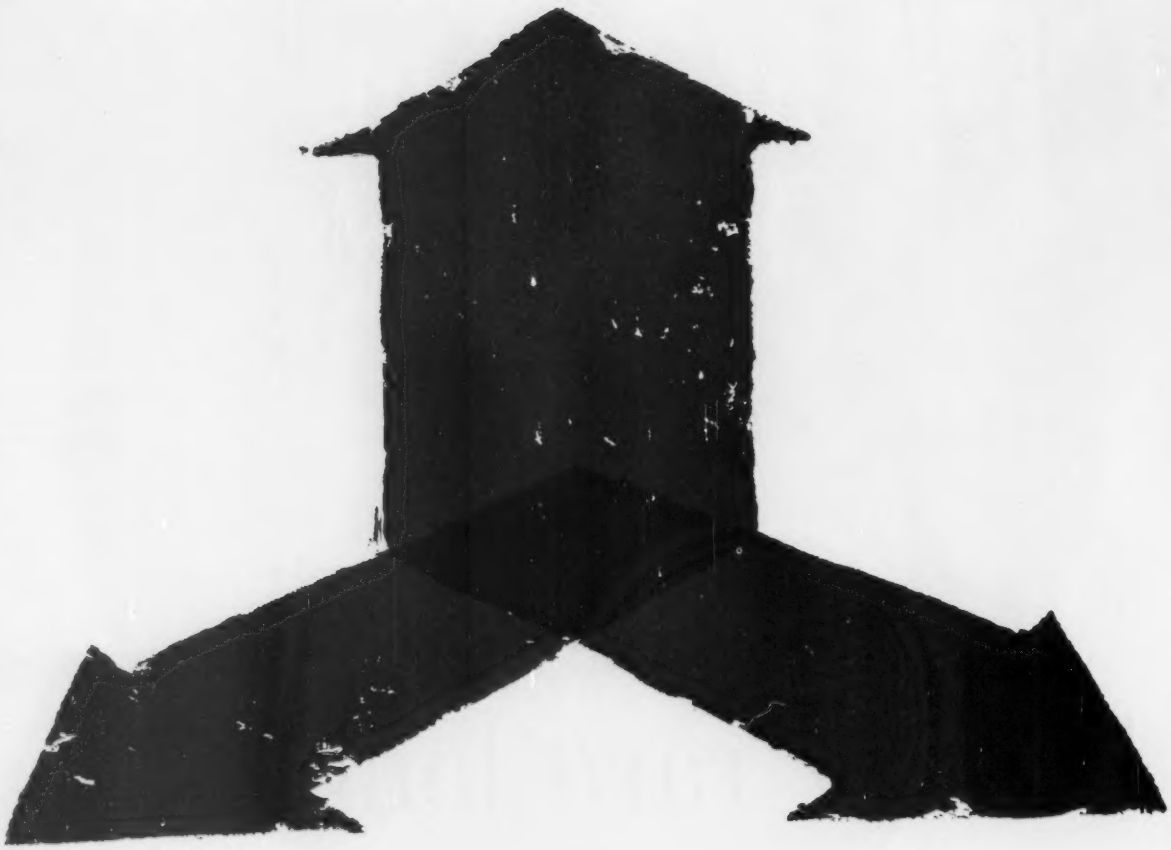
TERMINALS: Solder lug and taper tab.

KHP SERIES RELAY NOW AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO



Said Hans Oersted: *"When a conductor carries current through a magnetic field at right angles to it, the resultant reaction thrusts the conductor in a direction perpendicular to both the current and the magnetic field."*

A light-weight, low fuel-consuming propulsion system is a primary requirement for interplanetary space vehicle travel. One such system now being carefully studied utilizes plasma propulsion.

This concept employs an electrical field to produce a plasma and to energize it. A magnetic field then ejects the plasma, thereby providing a reactive thrust to the vehicle.

Plasma propulsion is but one of many subjects under investigation at Lockheed Missiles and Space Division. Outstanding facilities, equipment and scientific personnel mark the organization as eminently capable of exploring many unusual aspects of space travel. This, coupled with Lockheed's favorable locations in Sunnyvale and Palo Alto on the beautiful San Francisco Peninsula, consistently attracts scientists and engineers interested in pursuing work in their special fields.

Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-26 B, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

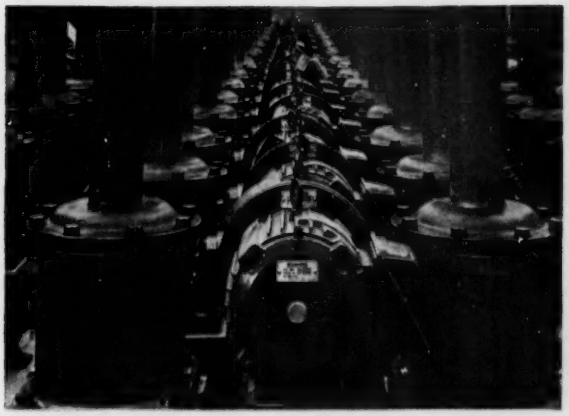
Lockheed / MISSILES AND SPACE DIVISION

Systems Manager for the Navy POLARIS FBM and the Air Force AGENA Satellite in the DISCOVERER and MIDAS Programs

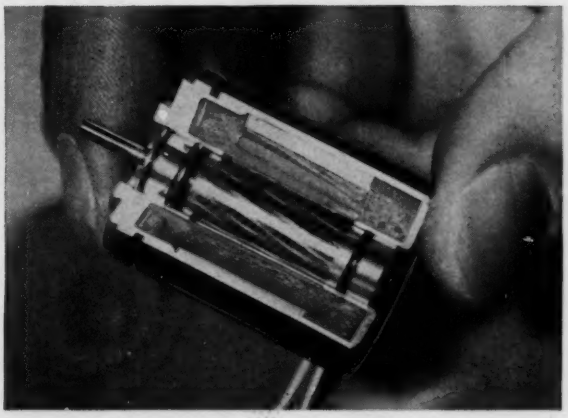
SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA • CAPE CANAVERAL, FLORIDA • HAWAII

SILICONE NEWS from Dow Corning

How To Get More Drive...



When the heat's on! Engineers for the Harvey Aluminum smelting plant at The Dalles, Oregon, take no chances on the reliability of anode feed motors in the electrolytic cell section. *Ambient temperatures are in the order of 300 F.* Harvey engineers specified Dow Corning silicone insulation for all 960 of the motors. Operated intermittently to adjust the carbon electrode level, these motors have the thermal stability to assure reliability despite the combined heat of high ambient and motor load.



From miniature motors! This servo motor intended for high temperature and humidity service has "sealed in" dependability with Dow Corning silicone insulation. Engineers at G-M Laboratories, Inc., Chicago, specify that the stator coils of this unit will be vacuum impregnated with Dow Corning solventless silicone resin and cured in an inert atmosphere. The cutaway picture shows how the resin completely fills the coil interstices and provides a solid bubble-free mass . . . seals out trouble.

Where the going is rough! Two 20-horsepower, a-c traction motors with Dow Corning silicone insulation keep mine production moving in spite of severe overloads and high temperatures. Goodman Manufacturing Co., Chicago, uses these motors on their four-wheel drive "584" shuttle car to assure the extra overload capacity needed for long life . . . dependable, easy, safe operation. If you need rugged motors for tight spots, specify Dow Corning silicone insulation.

For a reverse twist! On jobs that call for numerous drive reversals, you'll find Dow Corning silicone insulation eliminates frequent motor burn outs. Cadillac Gage of Detroit did. The motors—1-hp, 1800 rpm, Class A insulation—were required to make up to 100 reversals per minute. This created too much heat for the Class A insulation. Since putting silicone insulation to work, Cadillac Gage has not reported a bit of trouble with these lathe motors.

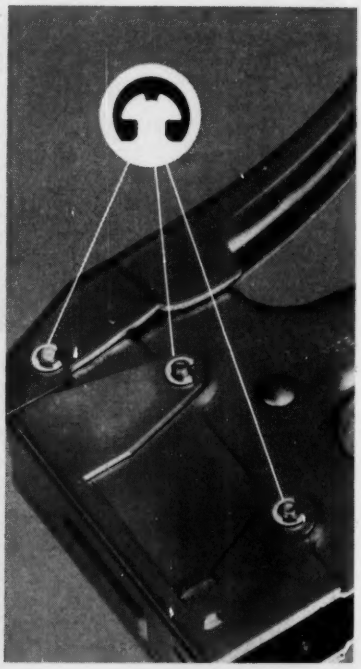
For the complete story on silicone insulated drives, write Dept. 6919a.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

Here's how ARROW FASTENER Co. gets Truarc® Retaining Rings FREE!



U.S. PAT. NO. 2,837,812

Mechanized Ring-O-Mat® designed by Truarc Engineers doubles stapler production for saving of $2500/year

Arrow Fastener Co., Inc., Brooklyn, N. Y., uses three Truarc Series 5144 reinforced E-rings to secure components in its Model T-50 compression stapler. Originally, Arrow operators installed the rings by hand with conventional applicators and dispensers. Fast? Sure — but Truarc engineers suggested to the company how the job could be done even faster and more economically by mechanizing the entire ring assembly operation.

Working closely with the Arrow engineering and production staff, Truarc mechanization engineers designed the unique Ring-O-Mat shown above. The unit installs the three E-rings in a single operation, twice as fast as the former hand method. Savings with the equipment are $2500 a year — enough to pay for all the rings the company uses!

Here's how the Ring-O-Mat works. The Truarc rings are supplied in tape-wrapped Rol-Pak® cartridges which are loaded on vertical magazine rails at the center of the unit. To install the rings, the operator merely places the stapler in a nest at the front and pushes the control buttons . . . the Ring-O-Mat does the rest! Applicators connected to the air cylinders grasp the bottom ring in each stack and move forward, seating the rings in accurately located grooves pre-cut in pivot pins extending through the body of the stapler. When the rings are fully seated, the applicators are withdrawn automatically and the operation is completed. Simple, fast, fool-proof — a typical example of how Truarc retaining rings lend themselves to mechanized assembly. A good example also of how you get *more* than a fastener when you buy Truarc!

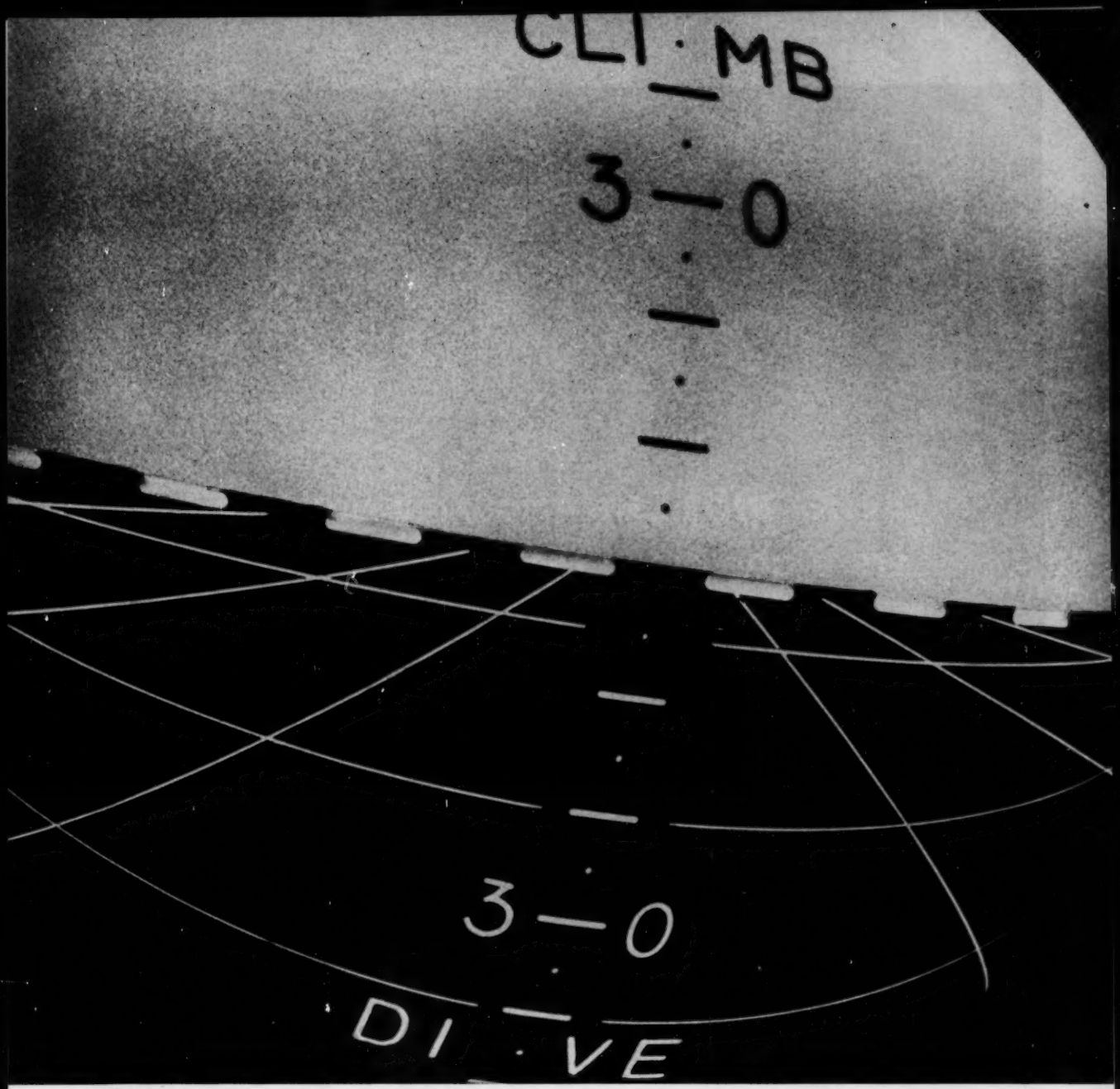
Interested in getting your retaining rings FREE?

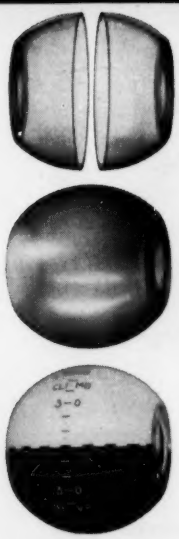
Bulletin 459-13 describes a number of assembly techniques for mass-production ring installation. Write for a copy or see your Truarc representative.

WALDES KOHINOOR, INC.

47-16 Austel Place, Long Island City 1, New York

61-5





Lexan resin provides dimensional stability in close-tolerance parts

Maximum change allowable in the overall dimensions of this five-inch attitude indicator component is only 5 mils over a temperature range of –65° to 300°F! Moreover, the aircraft instrument part must maintain these tolerances under conditions of high humidity. To meet these severe requirements for dimensional stability, Lear, Inc. selected LEXAN polycarbonate resin.

In addition to high performance, LEXAN offers easy and versatile fabrication. Thermoplastic, it is injection molded in half spheres which are joined by solvent cementing. After lathe turning to insure complete accuracy, the spheres are painted three different colors. Maximum visibility is obtained by lighting from the inside. With their high temperature resistance and high impact strength, these polycarbonate spheres are both rugged and precise design elements. They are fabricated for the Instrument Division of Lear, Inc. by Monroe Industries — both of Grand Rapids, Mich.

This component is an example of what high-performance LEXAN polycarbonate resin can do for your designs. The price of the resin has gone down, too, as production has gone up. Can *you* afford to overlook the major advantages of this new, major design material? Send for design literature.

LEXAN®
Polycarbonate Resin
GENERAL ELECTRIC

Chemical Materials Dept., Section MD-71, Pittsfield, Mass.

Circle 273 on Page 19

Single molding has red lens section, clear housing
On the 1961 Lark—Housing and lens are a one-piece Plexiglas molding!
In finished part, clear housing is metallized on second surface, small side-jewel section is sprayed red

The 1961 Studebaker Lark one-piece tail light "assembly" shown above is produced by double-molding red and crystal-clear PLEXIGLAS® acrylic plastic. The combined lens-and-housing is a first-time part in the automotive industry.

The advantages? An all-acrylic unit with handsome appearance, great strength and weather resistance, and a gleaming metallized section that stays bright . . . *at a cost reduction of approximately 30%* over the traditional assembly of lens, die-cast housing and gaskets.

There are many opportunities for obtaining improved performance at lower cost, in a wide range of products, by designing parts to be molded in PLEXIGLAS (and IMPLEX®, the high impact *acrylic*). We will be glad to send you information on these Rohm & Haas engineering materials.

ROHM & HAAS

PHILADELPHIA 5, PA.

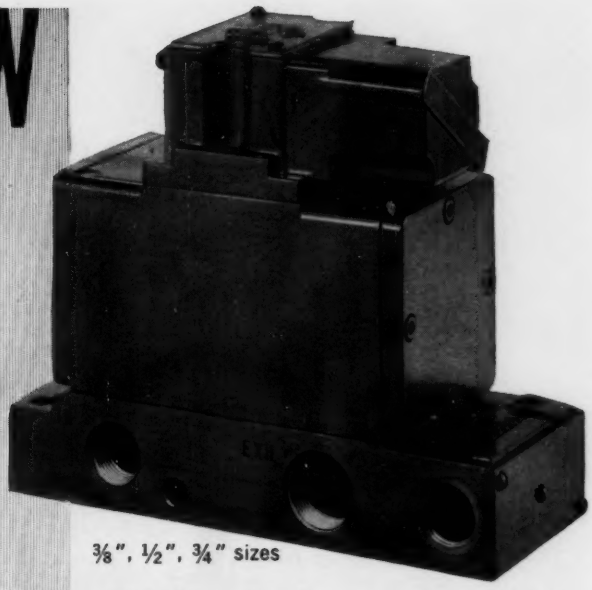
Detroit Representative: *R. C. Oglesby, Nor-Way Building, 20211 Greenfield Road, BRoadway 3-0674.*

In Canada: *Rohm & Haas Company of Canada, Ltd., West Hill, Ontario.*

PLEXIGLAS

Circle 274 on Page 19

NEW HANNIFIN "HUSTLER" VALVES GIVE YOU SPEED, SURENESS & GOOD SERVICE



3/8", 1/2", 3/4" sizes

ALL the features you want in 4-way, pilot-operated air control

HOW FAST? So fast it fills 12 cu. in. test chambers from 0 to 90 psi in 0.029 seconds. Larger, 100 cu. in. chambers fill in 0.075 seconds. Valve itself has been cycled on test over 3,000 times a minute. We know of no faster valve.

HOW SURE? Valve will operate on severely restricted air supplies and at pressures down to 15 psi, thanks to a reserve volume of pilot air, maintained at maximum line pressure in a self-restoring accumulator chamber (patent applied for). Low-wattage, nylon encapsulated, plug-in solenoids are guaranteed for life against burnout. New "Comb-O-Seals"—one-piece, pressure-energized—seal positively, cannot be improperly assembled. Any of today's varied air line lubricants can be used. Both pilot valve and main valves operate on poppet principle, cannot stick in dirty air.

HOW GOOD? Good for millions of leak-proof cycles! All-aluminum, die cast construction gives you light weight, assures clean, smooth air passages. Base mounting—all connections, air and electrical, are permanently made to the base. Quick plug-in feature —entire operating unit "plugs" into base; remove two screws and it lifts off easily and quickly. Locking manual over-ride is standard on all solenoid models. All models fully meet J.I.C. standards.

VALVES MOUNT ON 3 1/8" CENTERS

ADD-A-FOLD BASES (optional) permit joining a number of valves together, with one supply, one exhaust, one gallery for electrical connections.

You can have either maintained or momentary contact electrical actuation—or remote pressure actuation. Valve is available in 1/8", 1/4" and 3/4" pipe sizes. Write for new Bulletin 0611-B1.

PARKER HANNIFIN CORPORATION

HANNIFIN COMPANY
A DIVISION
515 South Wolf Road • Des Plaines, Illinois
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS
EUROPEAN DIVISION • PARKER-HANNIFIN N.V. • SCHIPHOL • THE NETHERLANDS

3419-PH

Switching from aluminum to Zamak sliced casting costs in half on this Whitehead ball bearing bobbin holder. And with seven zinc die castings accounting for all the major working parts, overall costs dropped a neat 12%.

This high volume item is found on spinning frames in cotton mills—it's designed to take twenty to thirty years of rugged, day-in day-out service. Yet by using Zamak instead of aluminum, the wall thickness of certain parts was reduced from .065" to .050". This resulted in a decrease in material cost with no loss in strength. Whitehead Die Casting plans to bring their costs down still further by going to wall thicknesses of .032"—with the toughness of the parts still unaffected as far as their performance goes.

Besides the healthy cost savings directly related to the reduced wall sections, Zamak also provides Whitehead with a familiar success story—"faster and more economical production . . . longer die life . . . less rejects." Zamak gives you more for less — — —

WHITEHEAD BALL BEARING BOBBIN HOLDER

AWARD OF MERIT

THE NEW JERSEY ZINC COMPANY'S "DIE CASTING OF THE YEAR" COMPETITION

CASTING COSTS CUT 50%

are YOU getting your METAL'S WORTH?

HORSE HEAD® SPECIAL ZINC AND HORSE HEAD ZAMAK ARE PRODUCED BY

THE NEW JERSEY ZINC COMPANY

160 FRONT STREET • NEW YORK 38, N. Y.

DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

HORSE HEAD PRODUCTS

MACHINE DESIGN
July 6, 1961

Later Than You Think?

ONE mark of a professional is the price he's paid for services rendered. What's happened to the salaries of engineers in the last decade is a measure of their growing stature.

EJC's 1960 *Professional Income of Engineers* and similar previous surveys—1953, 1956, 1958—depict gratifying increases for engineering graduates. From 1953 to 1960, the median annual salary for all engineering graduates advanced from $6500 to $9600.

The median starting salary in 1960 was 55.5 per cent above the 1953 figure. Salary of 10-year men at the median in 1960 was 59.5 per cent above that of 10-year men in 1953. The corresponding rise for 20-year men is 56 per cent.

However, if one follows the median individual from 1953 to 1960, the figures are even higher. The zero, 10, and 20-year men in 1953, who became 7, 17, and 27-year men in 1960, enjoyed incomes about 120, 90, and 60 per cent higher, respectively.

In the same period, the consumer price index rose 10.5 per cent, and the gross average weekly earnings of production workers in manufacturing increased 26.8 per cent.

These 1960 annual-income figures are worth pondering:

Grad. Year	Median	Upper Quartile	Upper Decile
'60	$ 6,350	$ 6,725	$ 7,250
'50	9,975	11,450	13,000
'40	12,500	15,000	17,700
'30	12,600	16,000	21,500

These data show the premiums paid in recent years for experience and performance. Performance has the edge. Mr. Upper Decile '50 is already paid more than either Mr. Median '40 or Mr. Median '30. Only the upper-decile club keeps from going over the hill. Generally, salaries tend to level or droop for classes before 1940, particularly for the median and below.

Technical obsolescence—not age—is probably the chief cause of the salary plateau of older (more experienced, ironically) engineers. While employers may share the responsibility of continuous updating of their engineers, the primary obligation is squarely upon engineers themselves. It may be later than you think!

Ben Hummel

EXECUTIVE EDITOR

A guide to

TECHNICAL

for effective control of the flow of technical information into and out of a company

- **Types of specifications**
- **Their administration and control**
- **Recommended format**
- **How to prepare them**

A. J. FITZGERALD
Manager, Product Engineering Dept.

ROWEN GLIE
Section Head, Engineering Standards

Maxson Electronics Corp.
New York, N. Y.

THE amount of information necessary to operate a modern engineering organization can assume staggering proportions. To meet this need, an efficient information-handling system is essential. Information must be gathered, checked, kept up to date, and made readily available where and when it is needed. Such a program requires a constant, organized company effort.

As a medium of information control, technical specifications have proved particularly effective. But exactly what is a technical specification? As defined here, a technical specification is a clear and accurate description of the technical requirements for a material, product, or service. It includes all applicable procedures for determining whether requirements have been fulfilled.

The specification reflects current company practice and may be narrow or specialized in scope and

Circle 14-2 on Page 19 for extra copy.

SPECIFICATIONS

subject. A standard, on the other hand, is "a specification accepted by recognized authorities as the most practical and appropriate current solution of a recurring problem."[1]

A specification defines what should and should not be done, how processes, components and equipment will be tested, what test results will be adequate and under what conditions a part will be rejected. In a proper specification vague assurances of quality such as "good commercial quality," "good workmanship," or "in accordance with state of the art" are replaced by precise testing methods, inspection procedures, and measurements. Problems of semantics between user, vendor, engineer, and shop are thereby minimized. Thus a specification provides a scientific approach to evaluation of materials, components, and processes.

Why Technical Specifications?

Descriptions of a company's technical requirements for manufacturing, testing procedures, materials, and components give the engineer a realistic basis for performing two important engineering functions:

1. Prediction of results.
2. Reproduction of the results.

Prediction of results is possible only with foreknowledge of materials, components, processes, and company facilities. To be widely available and useful, this knowledge must be presented in the form of well-organized specifications and/or standards.

Specifications and standards insure the ability to reproduce results. No product can be consistently reliable unless the manufacturer presents a complete set of "ground rules" in accordance with which the product is made. In addition to engineering drawings, specifications are the most important sources of company information.

There is a general misconception that a drawing alone gives sufficient information to the shop to manufacture the part represented. It has been shown that a drawing which is complete by all known drafting standards still presents many points of contention which need interpretation.[2] If the materials and processes necessary for the completion of the part are not covered by specifications, then such qualities and characteristics as strength, corrosion resistance, appearance, etc. will vary from day to day, from shop to shop, and from one worker to another.

A drawing released to the shop is a "go ahead" for a long sequence of various manufacturing and other operations. Specifications provide the engineering control for all activities which start after a drawing is released. Frequently, full engineering control over a new product developed by the company may necessitate specifications which precede the drawing-board design phase and initiate the engineering process.

What makes the specification so indispensable is the fact that it is impossible to manufacture two components identical in all respects. Practical engineering requirements call for compromise and approximation. The purpose of a specification is to define the parameters of these approximations and thereby limit the variations. By describing a process or a component and by limiting the variability of its characteristics, a specification controls the process or product; that is, it permits prediction and reproduction of results.

Specification Types

The operations performed by most companies usually involve specifications of the following types:

1. Engineering
2. Design
3. Product Performance
4. Manufacturing
5. Test
6. Purchase

The purpose of the last four types of specifications is readily apparent. However, the first two types—engineering and design—merit further explanation.

Engineering Specification: An engineering specification applies to new design or redesign. It is written to formulate and/or to clarify the objectives and implications of a user's problem, and the en-

[1]References are tabulated at end of article.

gineering solution to that problem. The thing to be avoided is the situation where an engineer, instead of solving the user's actual problem, solves what he *thinks* is the user's problem.

The following cases illustrate the point:

- Some time ago, Company X received a redesign job for one of the military services. The company had to supply some equipment which was successfully used on military planes during the Korean War. With the exception of a few insignificant changes,

11 Practical Rules for Preparing Technical Specifications

1. Avoid writing a new specification whenever possible. Try to adopt one already in existence. This practice can save time and money. National organizations which maintain current information in important subject areas are listed under *Sources of National and Industry Specifications, Standards, and Practices.*

2. Amend an available specification when it cannot be used "as is." If, for example, the existing spec is too specific where it should be general, and general where it should be specific, the spec should be amended as necessary and all suitable paragraphs copied as is. It is good practice to mention the basic specification in the "Applicable Documents" section of the company spec with the following note: "The following specification No. XXXXX is a part of this specification to the extent specified herein."

3. For each requirement of the specification, indicate a corresponding test procedure, cross referenced whenever practical. For example:

Requirement	Requirement Paragraph	Test Method Paragraph
Temperature Cycling	3.8	4.8
Plating Thickness	3.9	4.10
Moisture Resistance	3.10	4.12

4. Avoid devising test methods for internal company use only. Use the standards developed by ASTM, government, or other organizations as much as possible.

5. Assign a tolerance to each requirement or characteristic expressed as a numerical value. If the requirement is merely stated as 10 w, 100,000 psi, or 100 F., it does not tell the inspector what to do if the measured values are 10½ w, 999999 psi, or 99 or 101 F. For example; pressure tolerances may be expressed as:

100 000 psi ± 1000 psi	100,000 psi max
100,000 psi min to the nearest 100 psi	100,000 psi min

Tolerance to the nearest 100 psi means that all values over 99,950 are rounded off to 100,000 psi and accepted. All values less than 99,950 are rounded off to 99,900 psi and rejected.

The more selective the vendor must be to satisfy the specification, the more costly will be the product.

6. Specify only those requirements necessary to do the job. Each requirement will affect inspection procedures and ultimate cost. Be prepared to justify each requirement and to explain how it affects the end product. The following items should be carefully determined:

- Characteristics of the product to be controlled.
- Degree of control.

A partial list of environmental conditions and other requirements which might be covered in a specification is:

Temperature range	Life test
Altitude	Service test
Vibration	Shelf life
Shock	Radio interference
Humidity	Size and weight
Sea	Cooling
Sand and dust	Components application and quality
Sun and weathering	Human engineering
Air and waterproofing	
Explosion proofing	

Requirements for materials may include the following:

Chemical composition: Texture, color, odor

Physical Properties:

a. Density	h. Compression strength
b. Melting point	i. Yield strength
c. Thermal expansion	j. Creep strength
d. Specific heat	k. Shear strength
e. Modulus of elasticity	l. Elongation
f. Hardness	m. Impact
g. Tensile strength	n. Endurance limit

7. Specify a sampling plan, indicating how test specimens will be selected and inspected. For information on sampling procedure, the following publications are recommended:

MIL-STD-105—*Sampling Procedures and Tables for Inspection by Attributes*

MIL-E-5272—*Environmental Testing, Aeronautical and Associated Equipment*

MIL-STD-414—*Sampling Procedures and Tables for Inspection by Variable for Per Cent Defective*

MIL-STD-109—*Inspection Terms and Definitions*

ASTM—*Manual on Quality Control of Materials*

8. Be specific and aim for simplicity and clarity of expression. Specifications are read by all kinds of people — draftsmen, designers, purchasing agents, vendors, sales clerks, sales engineers, etc. A specification must be understood by everybody who will have to read it as a part of his job. It must be specific enough to avoid multiple interpretations of its requirements.

9. Never rely on catalog information alone when writing a specification. Component requirements are not always clearly spelled out in catalogs or similar literature and often require amplification.

10. When nonstandard or little known terms are used, do not hesitate to define them. For example:

Room temperature shall be 75 ± 12 F.

Sea level shall be to 10,000 ft

11. Keep in mind that a poorly written specification is better than none. Its shortcomings will not go unnoticed very long. In practice, feedback from those who use the spec will usually provide the information necessary for amendment or revision.

the equipment was to be manufactured as it was during the Korean War. Only after manufacturing had started was it suddenly realized that the equipment was to be used on the newest military aircraft having shock and vibration conditions such as to make the old equipment completely unsuitable for the purpose intended.

- Company Z received an order for an amplifier to be used on a plane. The amplifier was designed to withstand 10 G shock and actually tested at 25G. It worked perfectly. However, when installed on the plane, it failed. The equipment came back and was disassembled, checked, rechecked, and sent back for testing. Under service test it failed again. In the end, it was decided to investigate the situation on the plane itself. It was found that the amplifier was attached to a wall very close to the landing gear and so poorly isolated that at the moment of landing the amplifier was subjected to 40G shock load.

These examples show the hazards of relying on unverified information. Equipment requirements should be investigated from the user's point of view and under the true environmental conditions.

Many other cases could be cited in which a new design started with a hazy concept of the true need. Therefore, the purpose of an engineering specification is to put the project manager in the user's place to find out why, what, where, how, when, and, sometimes, even who.

Table 1—Translation of System Language to Design Specification

System Language	Design Specification*
Operation frequency range	Total useful travel of shorting plunger (forward face with respect to surface "A" of tube), XXX in. to XXX in.
Limits:	Permissible over travel of plunger:
a. High frequency (mc)	XXX in. to XXX in. (max)
b. Low frequency (mc)	XXX in. to XXX in. (min)
Tracking accuracy	Backlash between plunger and potentiometer (holding plunger) not to exceed 15 min; angular error, 10 min max.

*Oscillator cavity for radar system. Oscillation frequency is function of distance between oscillator tube and moving plunger. Limits define allowable travel beyond operating frequency range.

Design Specification: The primary purpose of a design specification is to translate system engineering language into that of design engineering. Table 1 illustrates how the semiabstract terms of system engineering are translated into the concrete electromechanical terms of a design specification.

The secondary purpose of a design specification is to provide a precise statement of all information the design engineer must have to successfully tackle the assignment. It will include requirements for performance, reliability, maintenance, human engineering, and standardization. The basic difference between the engineering specification and the design specification is that in the former the engineer tries to understand the user's problem and in the latter the designer tries to understand the engineer.

Bringing an abstract idea down to earth early in system development may save considerable expense —and some reputations. For instance, in writing a design specification for a recent project, a designer noted that the success of one abstract idea depended on the use of a synchronous 500 kc make-and-break switch. Translated into mechanical design language, this idea meant a wiper element rotating at 500,000 rpm. The idea was buried.

Specification Control

Creation and maintenance of a workable set of company specifications cannot be accomplished without administrative and engineering control. Originating, writing, approving, releasing, keeping up to date, amending, and cancelling must be done under constant control within a company's organizational setup. After all, specifications are not only a source of vital technical information. When sent to a vendor or a user, they may become legal documents of first

Specifications, Standards, and Practices Sources of National and Industry

American Institute of Electrical Engineers (AIEE)
33 W. 39th St., New York, N. Y.

American Society of Mechanical Engineers (ASME)
29 W. 39th St., New York, N. Y.

American Society of Quality Control (ASQC)
6197 Plankington Bldg., Milwaukee, Wis.

American Society for Testing Materials (ASTM)
1916 Race St., Philadelphia, Pa.

American Society of Tool and Manufacturing Engineers (ASTME)
10700 Puritan Ave., Detroit, Mich.

American Standards Association (ASA)
10 E. 40th St., New York, N. Y.

Copper and Brass Research Association (CABRA)
420 Lexington Ave., New York, N. Y.

Electronic Industry Association (EIA)
1721 De Sales St. N. W., Washington, D. C.

Institute of Printed Circuits (IPC)
27 E. Monroe St., Chicago, Ill.

Institute of Radio Engineers (IRE)
1 E. 79th St., New York, N. Y.

Instrument Society of America (ISA)
313 6th Ave., Pittsburgh, Pa.

Investment Casting Institute (ICI)
27 E. Monroe St., New York, N. Y.

Metal Powder Association (MPA)
130 W. 42nd St., New York, N. Y.

National Electrical Manufacturers Association (NEMA)
155 E. 44th St., New York, N. Y.

Society of Automotive Engineers (SAE)
485 Lexington Ave., New York, N. Y.

Society of Plastic Industry Inc. (SPI)
250 Park Ave., New York, N. Y.

U. S. Government

Office of Technical Services, Commodity Standard Div.
U. S. Dept. of Commerce, Washington 25, D. C.

Superintendent of Documents (For Military and Federal specs, and publications of National Bureau of Standards)
U. S. Government Printing Office, Washington 25, D. C.

importance. Since organizational setup varies from company to company, the methods of company specification control will vary too.

The document or "master control specification" which formulates the "standard" or "practice" for issuing technical specifications must contain more than straight administrative instructions. It should describe the control of technical specifications by covering the following items:

1. The purpose of the master control specification.
2. General definition of what a technical specification is.
3. Types of company specifications.
4. Purpose and scope for each type of company specification.
5. Responsibility for each specification.
6. Format of specification.
7. Procedures and control.
   a. Origination
   b. Approval
   c. Release
   d. Assignment of number
   e. Custody of Original
   f. Issuance of copies
   g. Changes—revisions, cancellation, reissue
   h. Cover sheet
   i. Specification pages and numbering system.

Pages from a typical master control specification are shown in Fig. 1. Administrative control of specifications may be defined by a chart, such as shown in Fig. 2. This chart delineates the responsibilities for origination, approval, amendment, and custody.

Specification Format

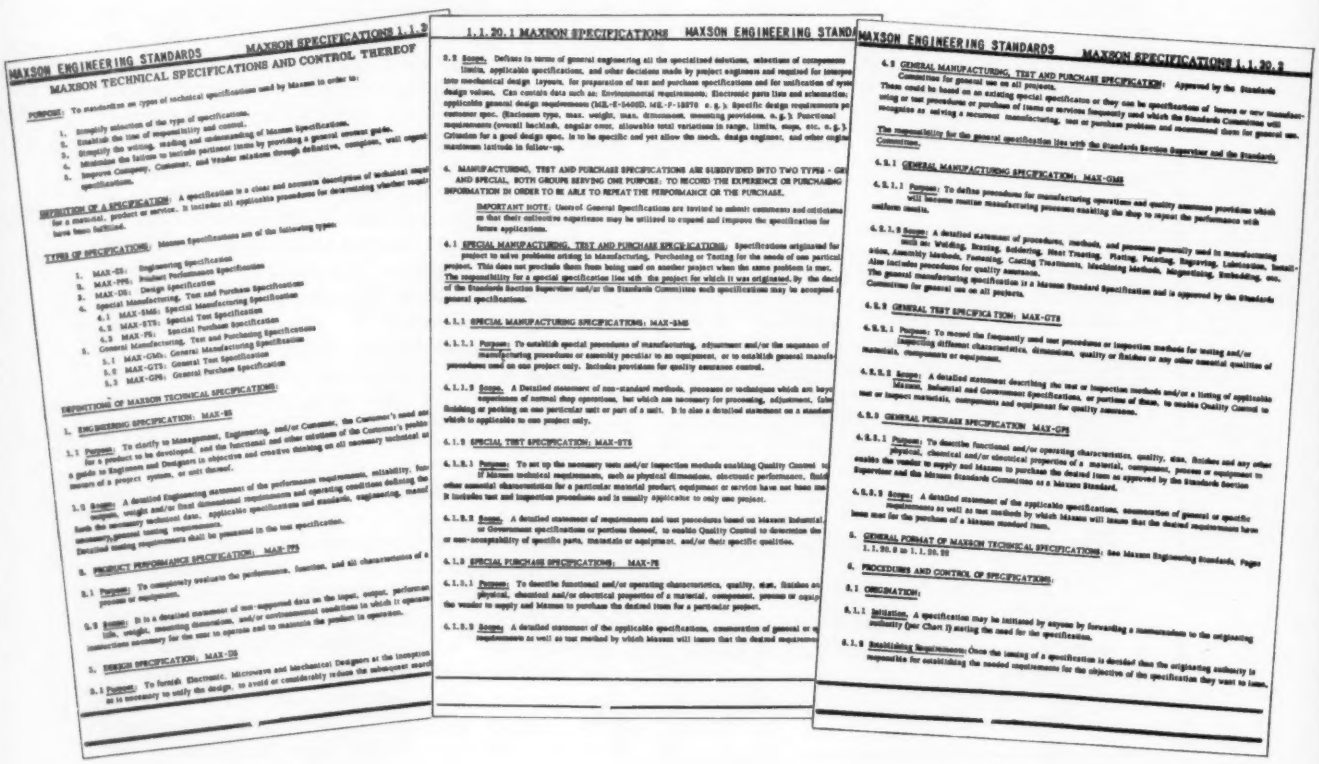
What type of specification format is best? Unfortunately, there is no pat answer that will apply to all situations. However, adopting the format of military specifications has the advantage of wide acceptance. Then, when company specifications are accepted on military jobs, the company and user are talking the same language. In addition, it is always easier to adopt an existing format than to create a new one. Furthermore, variation of specification formats is reduced across industry—which may be the most significant benefit of all.

Essentially the military-specification type of format consists of six sections:

1. SCOPE: This is a brief statement describing the item covered by the specification. In certain cases, particularly long purchase specifications, a short abstract of the specification requirements may be entered to assist a vendor to determine at a glance whether or not he has the item required. An abstract from a typical specification illustrates this technique:

> Scope: This specification covers the detail requirements for "Low Band Scan Driven Motor" (Maxson Functional Designation:) having the following characteristics:
> a. Motor type ..Synchronous, 400 cps, 3 phase, 200 line
> b. Size .....Size 15
> c. Speed .....6000 rpm
> d. Operating Temp .....−55 to +125 C (momentary at +200 C)
> e. Altitude .....Sea level to 100,000 ft

Fig. 1—Typical master control specification.


MAXSON ENGINEERING STANDARDS MAXSON SPECIFICATIONS 1.1.2

MAXSON TECHNICAL SPECIFICATIONS AND CONTROL THEREOF

PURPOSE: To standardize on types of technical specifications used by Maxson in order to:

1. Simplify selection of the type of specifications.
2. Establish the zone of responsibility and understanding of Maxson Specifications.
3. Simplify the writing, reading and understanding of Maxson Specifications.
4. Minimize the failure to include pertinent items by providing a general content guide.
5. Improve Company, Customer, and Vendor relations through definitive, complete, well organized specifications.

DEFINITION OF A SPECIFICATION: A specification is a clear and accurate description of technical requirements for a material, product or service. It includes all applicable procedures for determining whether requirements have been fulfilled.

TYPES OF SPECIFICATIONS: Maxson Specifications are of the following types:

1. MAX-ES: Engineering Specification
2. MAX-PPS: Product Performance Specification
3. MAX-DS: Design Specification
4. Special Manufacturing, Test and Purchase Specifications
   4.1 MAX-SMS: Special Manufacturing Specification
   4.2 MAX-STS: Special Test Specification
   4.3 MAX-PS: Special Purchase Specification
5. General Manufacturing, Test and Purchasing Specifications
   5.1 MAX-GMS: General Manufacturing Specification
   5.2 MAX-GTS: General Test Specification
   5.3 MAX-GPS: General Purchase Specification

DEFINITIONS OF MAXSON TECHNICAL SPECIFICATIONS:

1. ENGINEERING SPECIFICATION: MAX-ES

1.1 Purpose: To clarify to Management, Engineering, and/or Customer, the Customer's need and for a product to be developed, and the functional and other solutions of the Customer's problem a guide to Engineers and Designers in objective and creative thinking on all necessary technical a means of a project system, or unit thereof.

1.2 Scope: A detailed Engineering statement of the performance requirements, reliability, fun weight, weight and/or final dimensional requirements and operating conditions defining the limits the necessary technical data, applicable specifications and standards, engineering, manuf necessary, general testing requirements.
Detailed testing requirements shall be presented in the test specification.

2. PRODUCT PERFORMANCE SPECIFICATION: MAX-PPS

2.1 Purpose: To competently evaluate the performance, function, and all characteristics of a process or equipment.

2.2 Scope: It is a detailed statement of non-supported data on the input, output, performan life, weight, mounting dimensions, and/or environmental conditions in which it operates instructions necessary for the user to operate and to maintain the product in operation.

3. DESIGN SPECIFICATION: MAX-DS

3.1 Purpose: To furnish Electronic, Microwave and Mechanical Designers at the inception as is necessary to unify the design, to avoid or considerably reduce the subsequent redesi

1.1.20.1 MAXSON SPECIFICATIONS MAXSON ENGINEERING STAND

2.2 Scope: Defines in terms of general engineering all the specialized solutions, selections of components limits, applicable specifications, and other decisions made by project engineers and required for interpre into mechanical design layouts, for preparation of test and purchase specifications and for unification of syst design values. Can contain data such as: Environmental requirements, Electronic parts lists and schematics applicable general design requirements (MIL-E-5400D, MIL-P-16870 e. g.), Specific design requirements pe customer spec. (Enclosure type, max. weight, max. dimensions, mounting provisions, e. g.), Functional requirements (overall backlash, angular error, allowable total variations in range, limits, steps, etc. e. g.), Criterion for a good design spec. is to be specific and yet allow the mech. design engineer, and other engine maximum latitude in follow-up.

4. MANUFACTURING, TEST AND PURCHASE SPECIFICATIONS ARE SUBDIVIDED INTO TWO TYPES - GE AND SPECIAL, BOTH GROUPS SERVING ONE PURPOSE. TO RECORD THE EXPERIENCE OR PURCHASING INFORMATION IN ORDER TO BE ABLE TO REPEAT THE PERFORMANCE OR THE PURCHASE.

IMPORTANT NOTE: Unusual General Specifications are invited to submit comments and criticisms so that their collective experience may be utilized to expand and improve the specification for future applications.

4.1 SPECIAL MANUFACTURING, TEST AND PURCHASE SPECIFICATIONS: Specifications originated for project to solve problems arising in Manufacturing, Purchasing or Testing for the needs of one particul project. This does not preclude them from being used on another project when the same problem is met. The responsibility for a special specification lies with the project for which it was originated, by the decisi of the Standards Section Supervisor and/or the Standards Committee such specifications may be accepted general specifications.

4.1.1 SPECIAL MANUFACTURING SPECIFICATIONS: MAX-SMS

4.1.1.1 Purpose: To establish special procedures of manufacturing, adjustment and/or the sequence of manufacturing procedures or assembly peculiar to an equipment, or to establish general manufa procedures used on one project only. Includes provisions for quality assurance control.

4.1.1.2 Scope: A Detailed statement of non-standard methods, processes or techniques which are beyo experience of normal shop operations, but which are necessary for processing, adjustment, fabr finishing or packing on one particular unit or part of a unit. It is also a detailed statement on a standard which is applicable to one project only.

4.1.2 SPECIAL TEST SPECIFICATION: MAX-STS

4.1.2.1 Purpose: To set up the necessary tests and/or inspection methods enabling Quality Control to If Maxson technical requirements, such as physical dimensions, electronic performance, finish other essential characteristics for a particular material product, equipment or service have not been me it includes test and inspection procedures and is usually applicable to only one project.

4.1.2.2 Scope: A detailed statement of requirements and test procedures based on Maxson Industrial, or Government specifications or portions thereof, to enable Quality Control to determine the or non-acceptability of specific parts, materials or equipment, and/or their specific qualities.

4.1.3 SPECIAL PURCHASE SPECIFICATIONS: MAX-PS

4.1.3.1 Purpose: To describe functional and/or operating characteristics, quality, size, finishes an physical, chemical and/or electrical properties of a material, component, process or equip the vendor to supply and Maxson to purchase the desired item for a particular project.

4.1.3.2 Scope: A detailed statement of the applicable specifications, enumeration of general or s requirements as well as test method by which Maxson will insure that the desired requirem

MAXSON ENGINEERING STANDARDS MAXSON SPECIFICATIONS 1.1.20.2

4.2 GENERAL MANUFACTURING, TEST AND PURCHASE SPECIFICATION: Approved by the Standards Committee for general use on all projects.
These could be based on an existing special specification or they can be specifications of known or new manufacturing or test procedures or purchase of items or services frequently used which the Standards Committee will recognize as serving a recurrent manufacturing, test or purchase problem and recommend them for general use.

The responsibility for the general specification lies with the Standards Section Supervisor and the Standards Committee.

4.2.1 GENERAL MANUFACTURING SPECIFICATION: MAX-GMS

4.2.1.1 Purpose: To define procedures for manufacturing operations and quality assurance provisions which will become routine manufacturing processes enabling the shop to repeat the performance with uniform results.

4.2.1.2 Scope: A detailed statement of procedures, methods, and processes generally used in manufacturing such as: Welding, Brazing, Soldering, Heat Treating, Plating, Painting, Engraving, Lubrication, Installation, Assembly Methods, Fastening, Casting Treatments, Machining Methods, Magnetizing, Embedding, etc. Also includes procedures for quality assurance.
The general manufacturing specification is a Maxson Standard Specification and is approved by the Standards Committee for general use on all projects.

4.2.2 GENERAL TEST SPECIFICATION: MAX-GTS

4.2.2.1 Purpose: To record the frequently used test procedures or inspection methods for testing and/or inspecting different characteristics, dimensions, quality or finishes or any other essential qualities of materials, components or equipment.

4.2.2.2 Scope: A detailed statement describing the test or inspection methods and/or a listing of applicable Maxson, Industrial and Government Specifications, or portions of these, to enable Quality Control to test or inspect materials, components and equipment for quality assurance.

4.2.3 GENERAL PURCHASE SPECIFICATION MAX-GPS

4.2.3.1 Purpose: To describe functional and/or operating characteristics, quality, size, finishes and any other physical, chemical and/or electrical properties of a material, component, process or equipment to enable the vendor to supply and Maxson to purchase the desired item as approved by the Standards Section Supervisor and the Maxson Standards Committee as a Maxson Standard.

4.2.3.2 Scope: A detailed statement of the applicable specifications, enumeration of general or specific requirements as well as test methods by which Maxson will insure that the desired requirements have been met for the purchase of a Maxson standard item.

5. GENERAL FORMAT OF MAXSON TECHNICAL SPECIFICATIONS: See Maxson Engineering Standards, Pages 1.1.20.0 to 1.1.20.20

6. PROCEDURES AND CONTROL OF SPECIFICATIONS:

6.1 ORIGINATION:

6.1.1 Initiation: A specification may be initiated by anyone by forwarding a memorandum to the originating authority (See Chart 1) stating the need for the specification.

6.1.2 Establishing Requirements: Once the issuing of a specification is decided then the originating authority is responsible for establishing the needed requirements for the objective of the specification they want to issue.

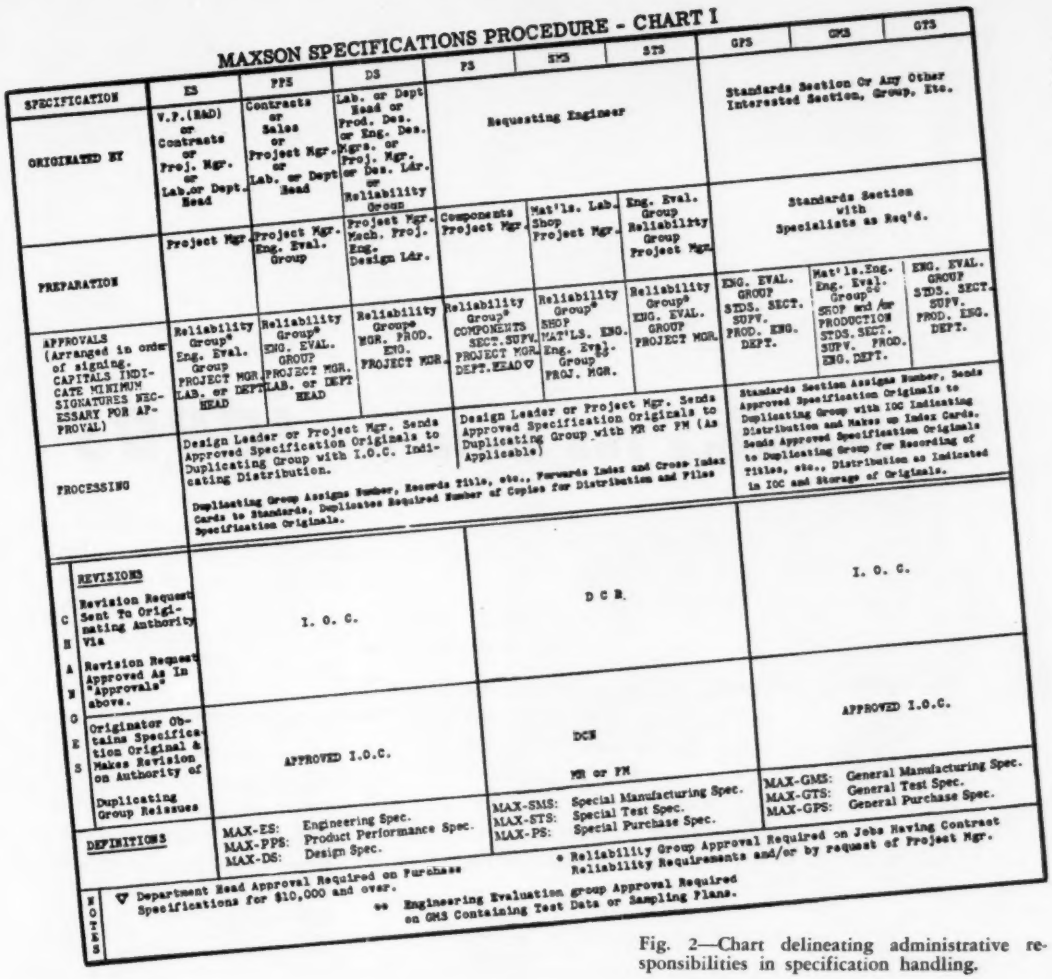

MAXSON SPECIFICATIONS PROCEDURE - CHART I
SPECIFICATION
ES
PPS
DS
PS
SMS
STS
GPS
GMS
GTS
ORIGINATED BY
V.P.(R&D) or Contracts or Proj. Mgr. or Lab.or Dept. Head
Contracts or Sales or Project Mgr. or Lab. or Dept. Head
Lab. or Dept Head or Prod. Des. or Eng. Des. Mgrs. or Proj. Mgr. or Des. Ldr. or Reliability Group
Requesting Engineer
Standards Section Or Any Other Interested Section, Group, Etc.
PREPARATION
Project Mgr.
Project Mgr. Eng. Eval. Group
Project Mgr. Mech. Proj. Engr. Design Ldr.
Components Project Mgr.
Mat'ls. Lab. Shop Project Mgr.
Eng. Eval. Group Reliability Group Project Mgr.
Standards Section with Specialists as Req'd.
APPROVALS (Arranged in order of signing. CAPITALS INDICATE MINIMUM SIGNATURES NECESSARY FOR APPROVAL)
Reliability Group* Eng. Eval. Group PROJECT MGR. LAB. or DEPT. HEAD
Reliability Group* ENG. EVAL. GROUP PROJECT MGR. LAB. or DEPT HEAD
Reliability Group* MGR. PROD. ENG. PROJECT MGR.
Reliability Group* COMPONENTS SECT. SUPV. PROJECT MGR. DEPT. HEAD ▽
Reliability Group* SHOP MAT'LS. ENG. Eng. Eval. Group PROJ. MGR.
Reliability Group* ENG. EVAL. GROUP PROJECT MGR.
ENG. EVAL. GROUP STDS. SECT. SUPV. PROD. ENG. DEPT.
Mat'ls.Eng. Eval. Group** SHOP and/or PRODUCTION STDS. SECT. SUPV. PROD. ENG. DEPT.
ENG. EVAL. GROUP STDS. SECT. SUPV. PROD. ENG. DEPT.
PROCESSING
Design Leader or Project Mgr. Sends Approved Specification Originals to Duplicating Group with I.O.C. Indicating Distribution.
Design Leader or Project Mgr. Sends Approved Specification Originals to Duplicating Group with MR or PN (As Applicable)
Standards Section Assigns Number, Sends Approved Specification Originals to Duplicating Group with IOC Indicating Distribution and Makes up Index Cards. Sends Approved Specification Originals to Duplicating Group for Recording of Titles, etc., Distribution as Indicated in IOC and Storage of Originals.
Duplicating Group Assigns Number, Records Title, etc., Forwards Index and Cross Index Cards to Standards, Duplicates Required Number of Copies for Distribution and Files Specification Originals.
CHANGES
REVISIONS
Revision Request Sent To Originating Authority Via
I. O. C.
D C R.
I. O. C.
Revision Request Approved As In "Approvals" above.
Originator Obtains Specification Original & Makes Revision on Authority of
APPROVED I.O.C.
DCR
MR or PN
APPROVED I.O.C.
Duplicating Group Reissues
DEFINITIONS
MAX-ES: Engineering Spec.
MAX-PPS: Product Performance Spec.
MAX-DS: Design Spec.
MAX-SMS: Special Manufacturing Spec.
MAX-STS: Special Test Spec.
MAX-PS: Special Purchase Spec.
MAX-GMS: General Manufacturing Spec.
MAX-GTS: General Test Spec.
MAX-GPS: General Purchase Spec.
NOTES
▽ Department Head Approval Required on Purchase Specifications for $10,000 and over.
* Reliability Group Approval Required on Jobs Having Contract Reliability Requirements and/or by request of Project Mgr.
** Engineering Evaluation group Approval Required on GMS Containing Test Data or Sampling Plans.

Fig. 2—Chart delineating administrative responsibilities in specification handling.

f. Running torque .....1.0 oz-in. min at 6000 rpm
g. Starting torque .....1.5 oz-in. min
h. Acceleration time
over temp. range .....20 sec max for 2.5 oz-in.^{2} load
i. Vibration .....10-2000 cps, 30g
j. Shock .....100g 11 ms
k. Acceleration .....15 g

2. Applicable Documents: This section provides reference information on which documents, government specifications, specification control drawings, and AIEE, EIA, ASA, NEMA, and other specifications, are part of the company technical specification.

3. Requirements: This section contains all essential requirements and descriptions applicable to design, materials, or product covered by the specification. When the specification contains many types or classes, the general requirements for all are given first, followed by the individual requirements.

4. Quality Assurance Provisions: This section provides detailed information on classification, test methods, and methods and frequency of sampling. Test methods, when practicable, are arranged in the same consecutive order as the corresponding requirements in section 3.

5. Preparation for Delivery: This section contains information on packaging requirements necessary to prevent breakage or other damage.

6. Notes: This section will contain general or explanatory information. Specific requirements should not appear here but in section 3. This section may include the following topics: a. Intended use. b. Standard samples. c. Suggested features.

A seventh section—certification—may be included when applicable (usually a purchase specification requirement). Certification requires manufacturers to provide written assurance that all units furnished under a specification are in full compliance with its provisions.

Complete details covering the format of military specifications are given in a standardization manual, which is generally available.[3] This manual coincides in many respects with the style manual of the American Standards Association.[4]

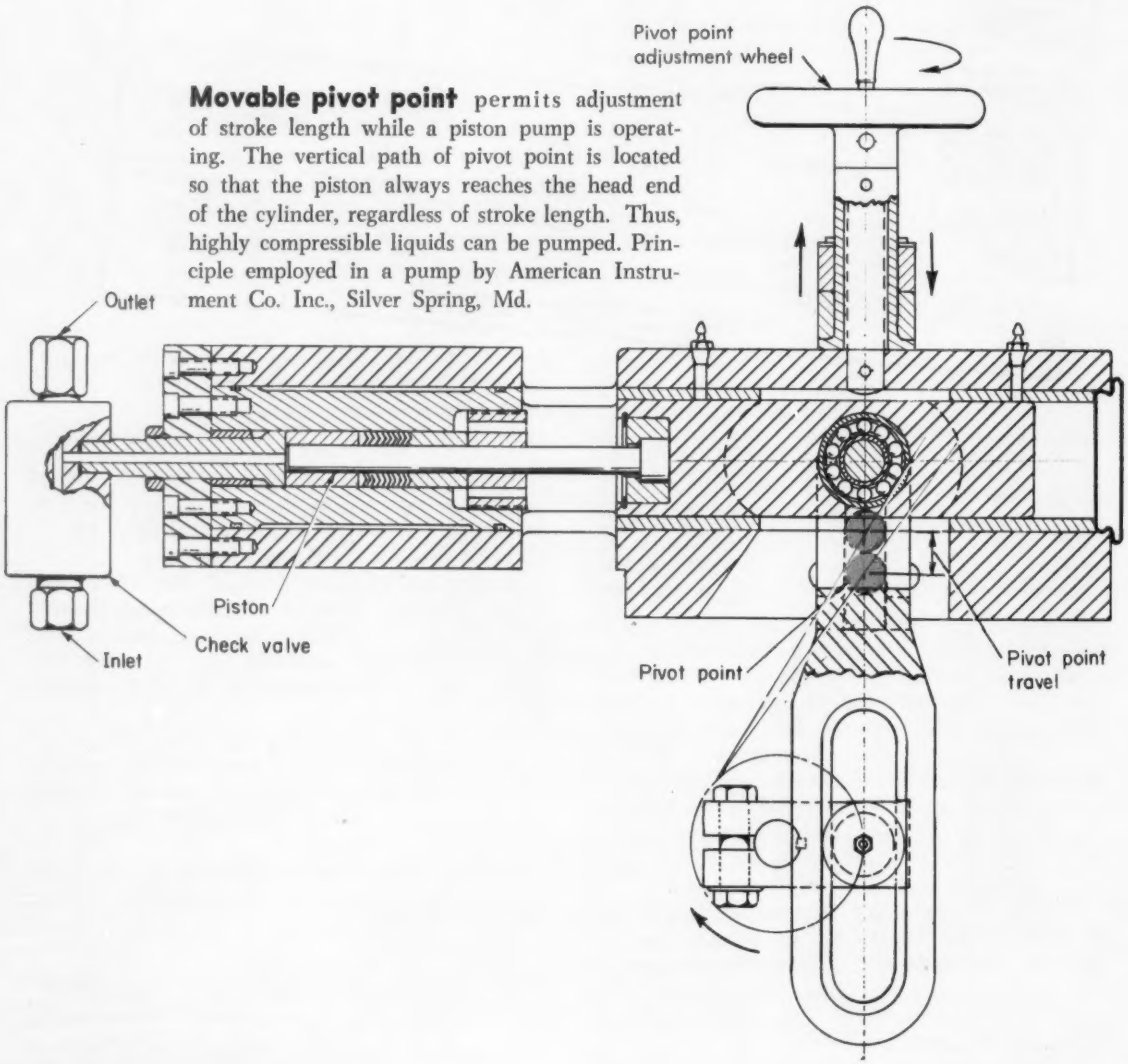
Some practical rules to follow in writing specifications for company use are given in *Preparing Technical Specifications.*

References

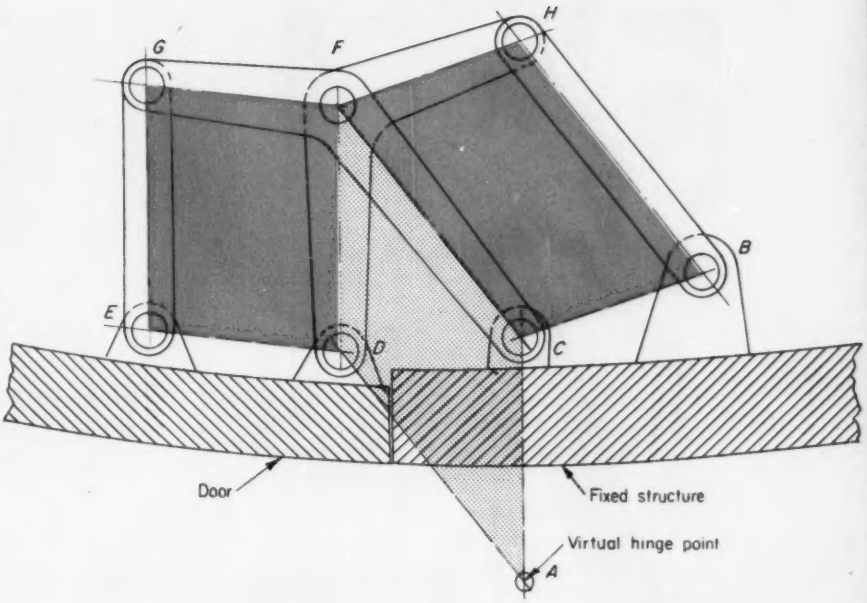
1. J. A. Chingas and R. Glie—"Definitions in Standardizations," *Magazine of Standards*, Oct. 1959.
2. J. A. Chingas—"Shop Practice Standard," Machine Design, Vol. 30, No. 11, May 29, 1958.
3. Standardization Manual M-205—*Military Outline of Form and Instructions for the Preparation of Specification*, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.
4. *Style Manual*, American Standards Association, 10 East 40th St., New York 16, N. Y., 1960.

scanning the field for *ideas*

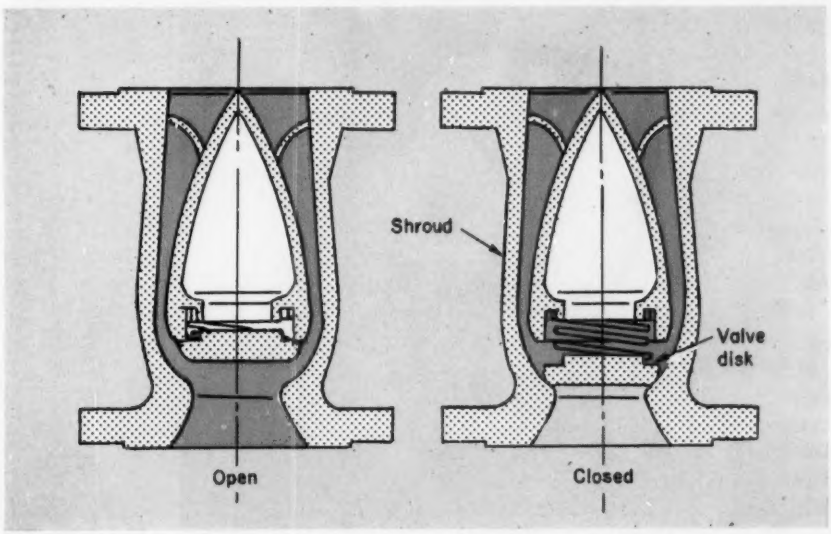
Movable pivot point permits adjustment of stroke length while a piston pump is operating. The vertical path of pivot point is located so that the piston always reaches the head end of the cylinder, regardless of stroke length. Thus, highly compressible liquids can be pumped. Principle employed in a pump by American Instrument Co. Inc., Silver Spring, Md.



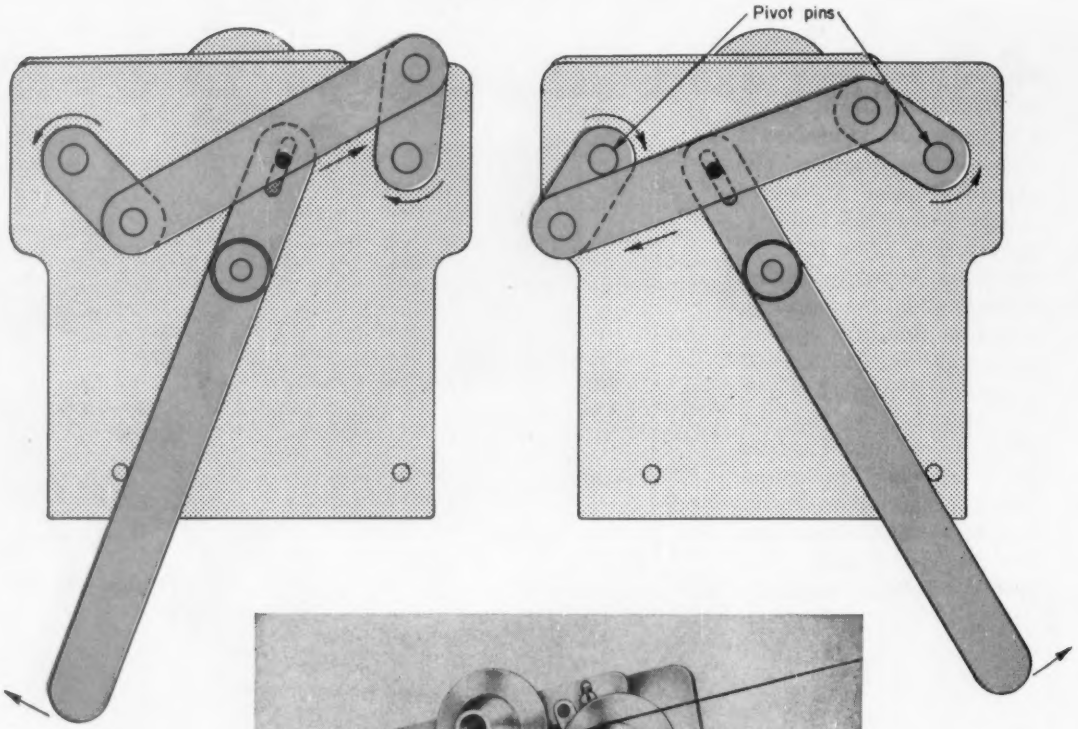
Virtual hinge point can be designed easily to permit a swinging door to operate in a double-curved surface. Virtual hinge point *A* (located outside the structure) and linkage attaching points *B*, *C*, *D*, and *E* are arbitrarily selected. Points *A*, *C*, *D*, and *F* are connected so that *AD* is equal and parallel to *CF*, and *AC* is equal and parallel to *DF*. The remaining two parallelograms are constructed and the points connected by linkage. Principle employed in aircraft-door linkage by Technical Publications and Supplies Ltd., East Twickenham, England.

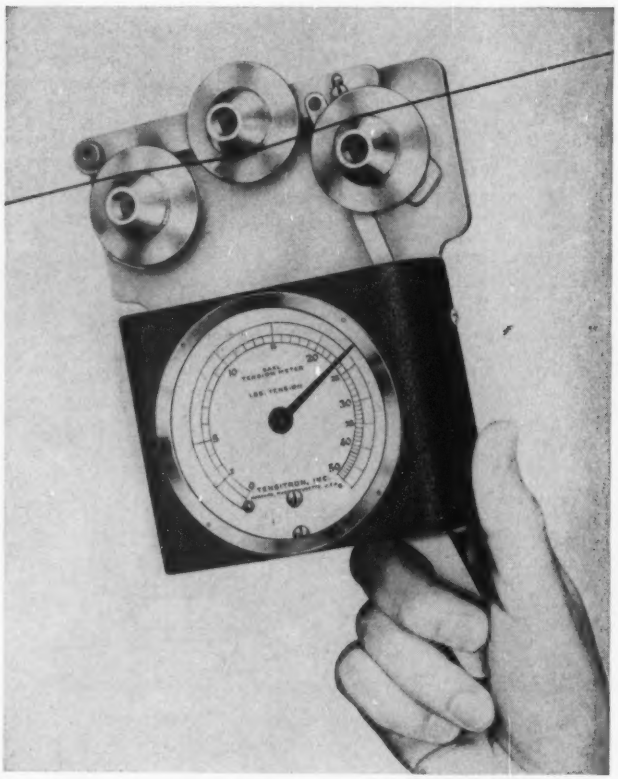


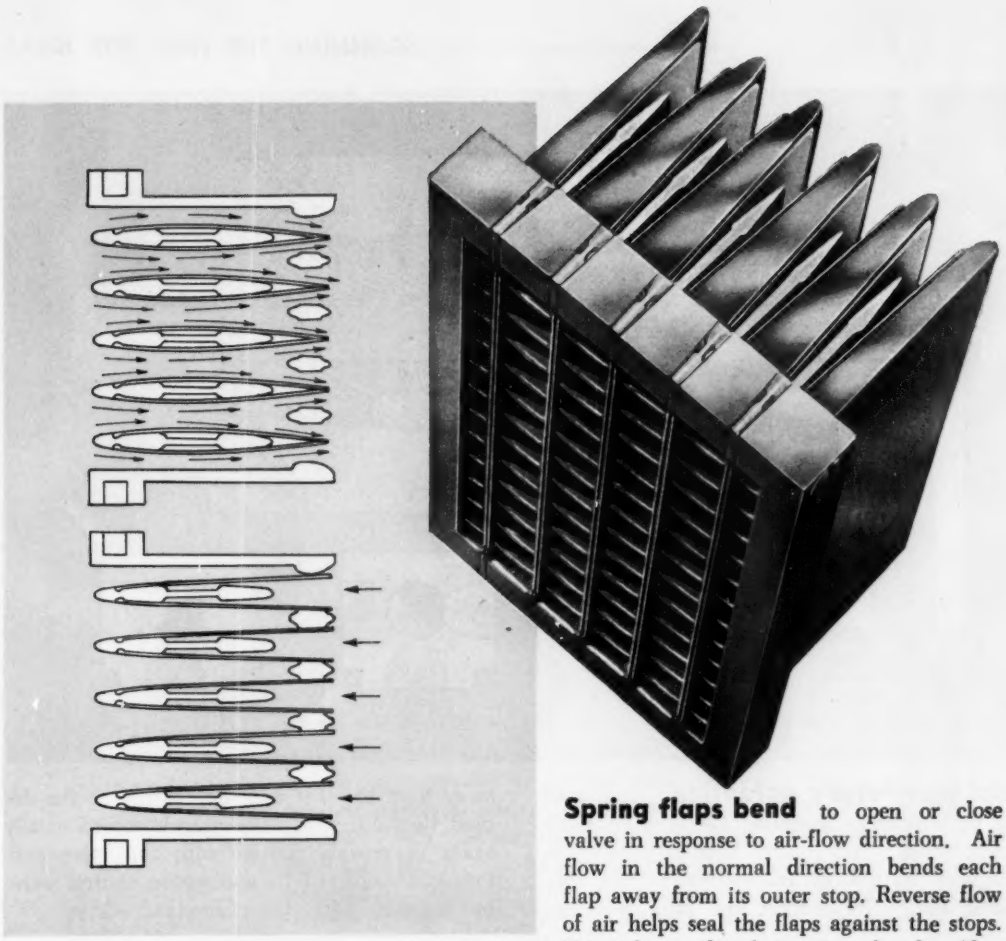
Tapered valve shroud produces gradual decrease of annular flow area as the valve closes against the flow. Thus, no surge, or "water hammer" is produced. Principle employed in a check valve designed by Mannesman-Meer, Moenchengladbach, Germany.



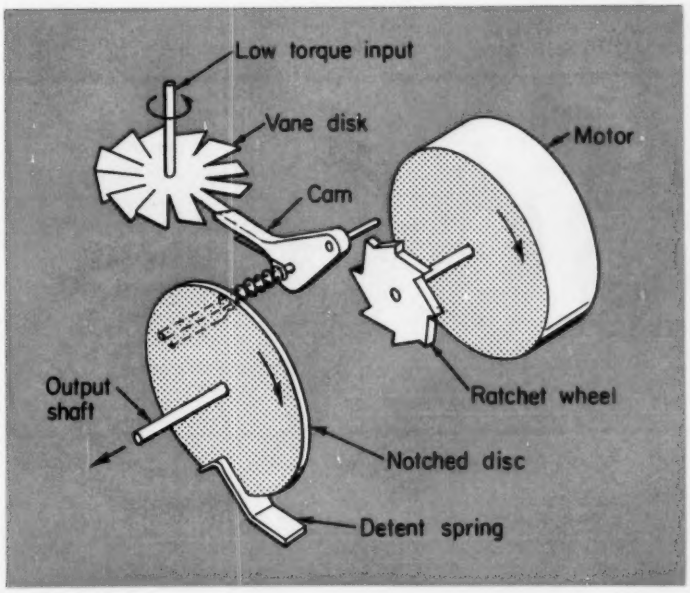
Pin-and-slot linkage provides equal, but opposite, rotation of pivot pins in response to simple movement of hand lever. Short arms attached to the pivot pins support rollers which are thus moved in relation to a tension-measuring roller. Actuation principle employed in a tension meter developed by Erwin J. Saxl of Tensitron Inc., Harvard, Mass.



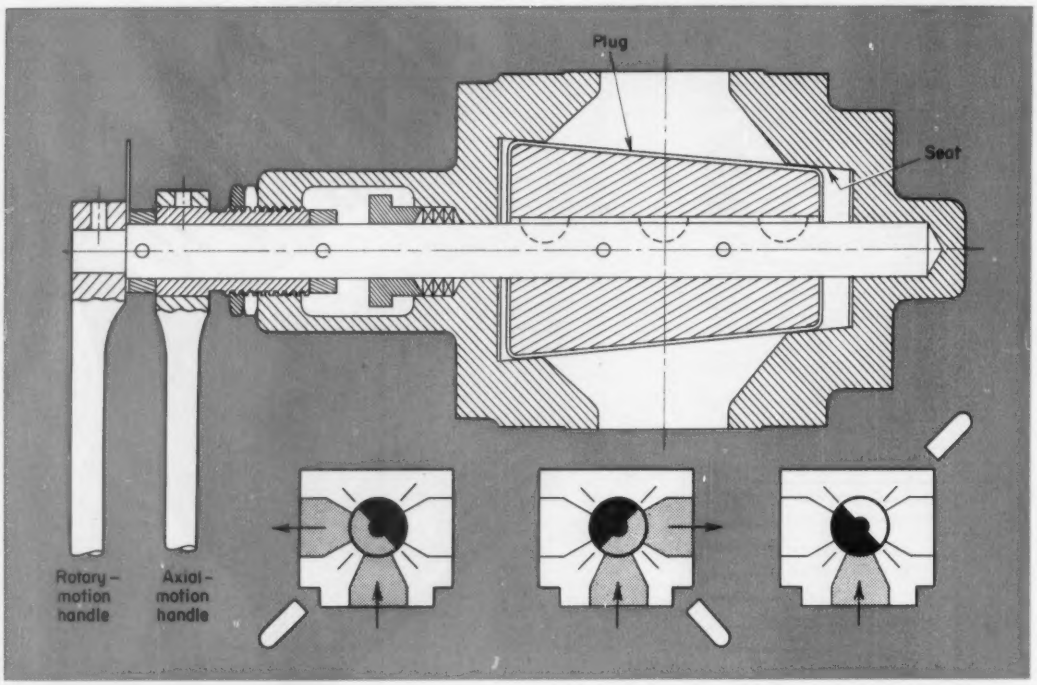




Spring flaps bend to open or close valve in response to air-flow direction. Air flow in the normal direction bends each flap away from its outer stop. Reverse flow of air helps seal the flaps against the stops. Principle employed in air valve by Alan Muntz and Co. Ltd., Feltham, England.

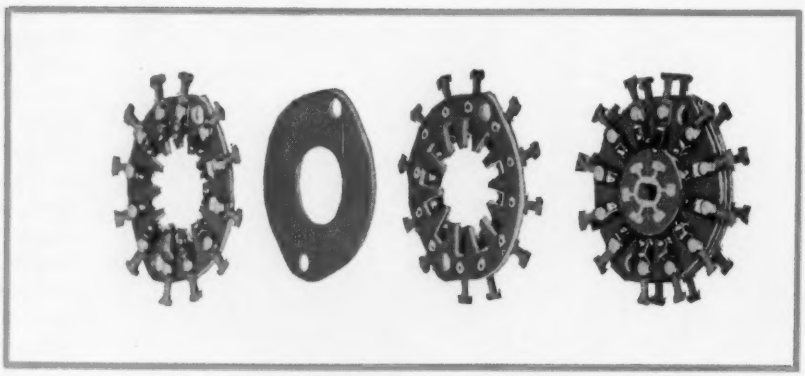


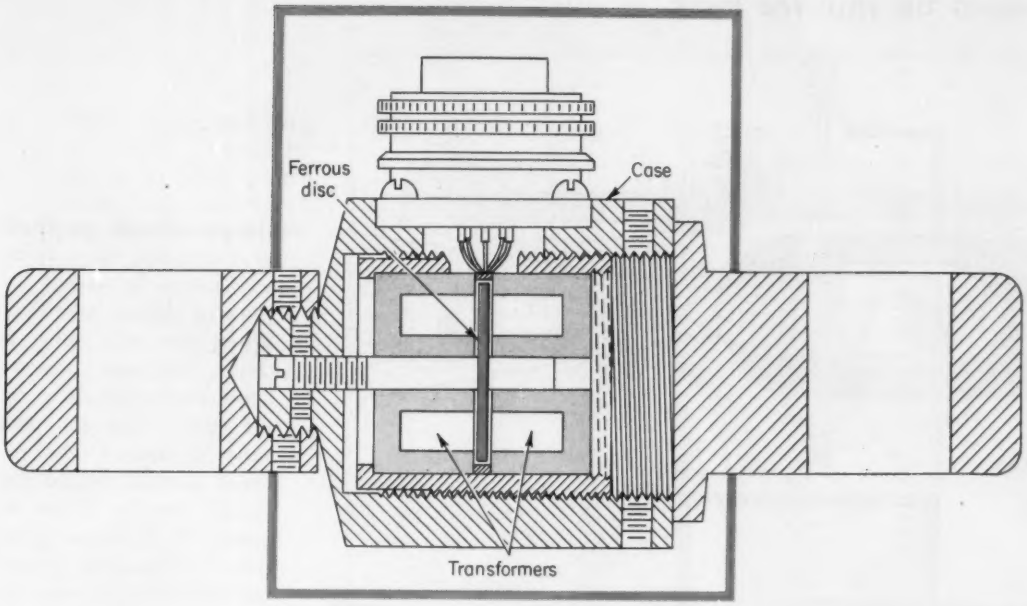
Vane released cam triggers torque multiplier. The cam, released by a slowly rotating vaned disc, engages a continuous rotating ratchet wheel to turn an output shaft one revolution. The cam then engages the next vane on the disc and disengages from the ratchet wheel. Thus, frequency of operation of the output shaft depends upon the speed of the vane disc, but the output torque is supplied by the motor-driven ratchet wheel. Principle employed in a recording watt-hour meter by Siemens-Schuckertwerke AG, Nuremberg, Germany.



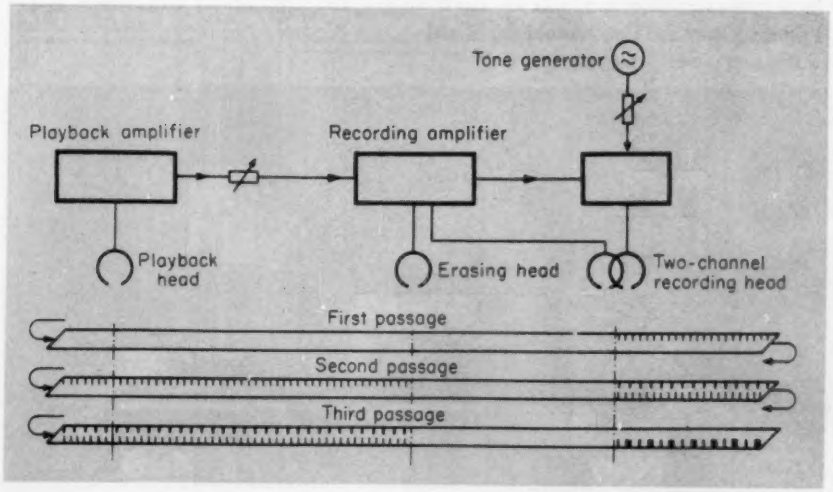
Axial plus rotary actuation of a tapered plug valve provides increased tolerance for solids in suspension. Two control handles provide independent control of movements of the soft, tapered plug. To operate, the plug is pulled away from the seat and then turned to the desired flow direction. The plug is moved axially again to provide contact with the valve seat. Principle employed in a direction control valve by Republic Mfg. Co., Cleveland, Ohio.

Triple-wafer deck doubles the usual capability of a subminiature rotary switch. Thus, up to 24 contacts can be provided within a 1-in. overall diameter. Principle employed in a switch by J-B-T Instruments Inc., New Haven, Conn.

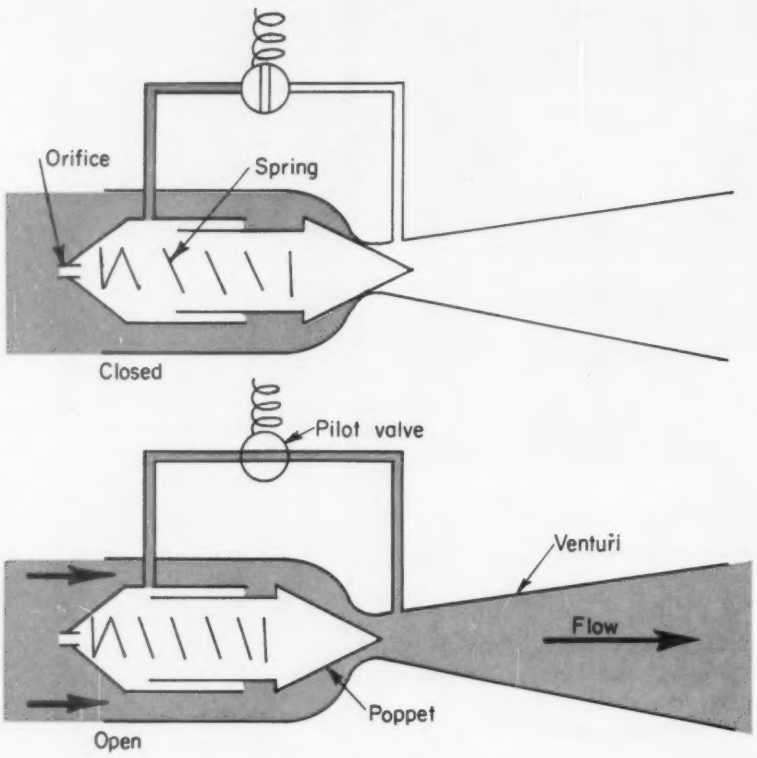




Load-displaced disc, positioned between matched transformers, controls output current in proportion to applied load. Thus, a direct electrical readout of applied load is obtained. Principle employed in a load cell developed by W. C. Dillon and Co. Inc., Van Nuys, Calif.

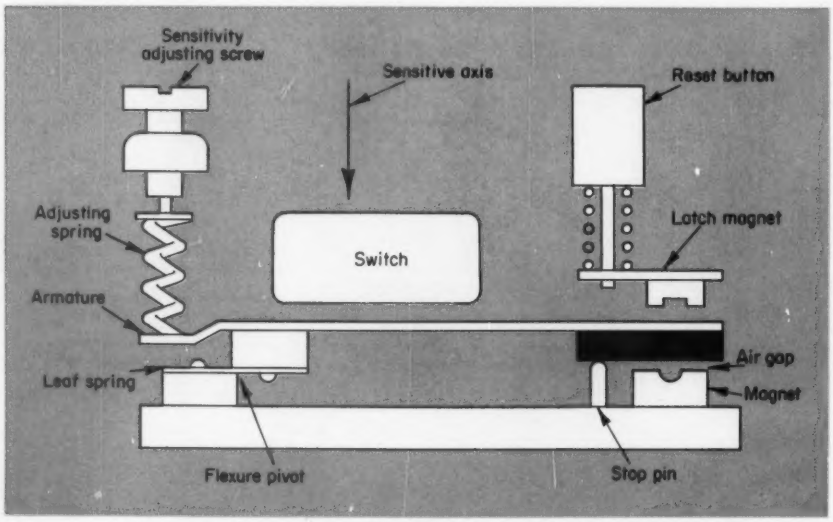


Twin-recording heads synchronize "multiple-exposure" sounds to produce artificial music from pure tones. The initial input is recorded on the upper sound track. During second recording, this initial input is transferred to the lower track and the upper track is erased to receive the second input. This process can be repeated to combine any desired number of inputs onto the lower sound track. Principle employed in tape recorder by Eberhard Vollmer, Plochingen, Germany.

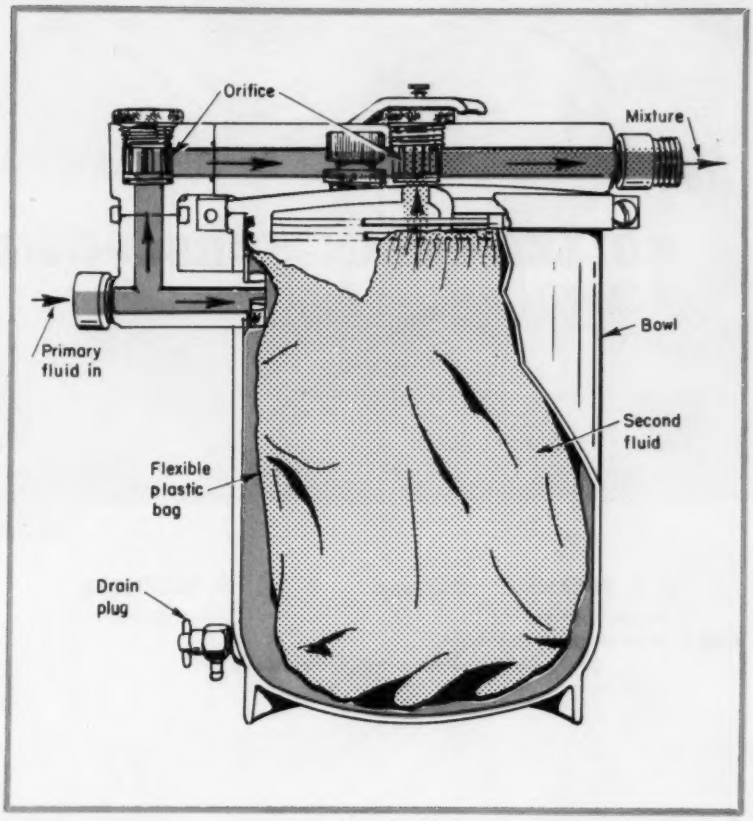


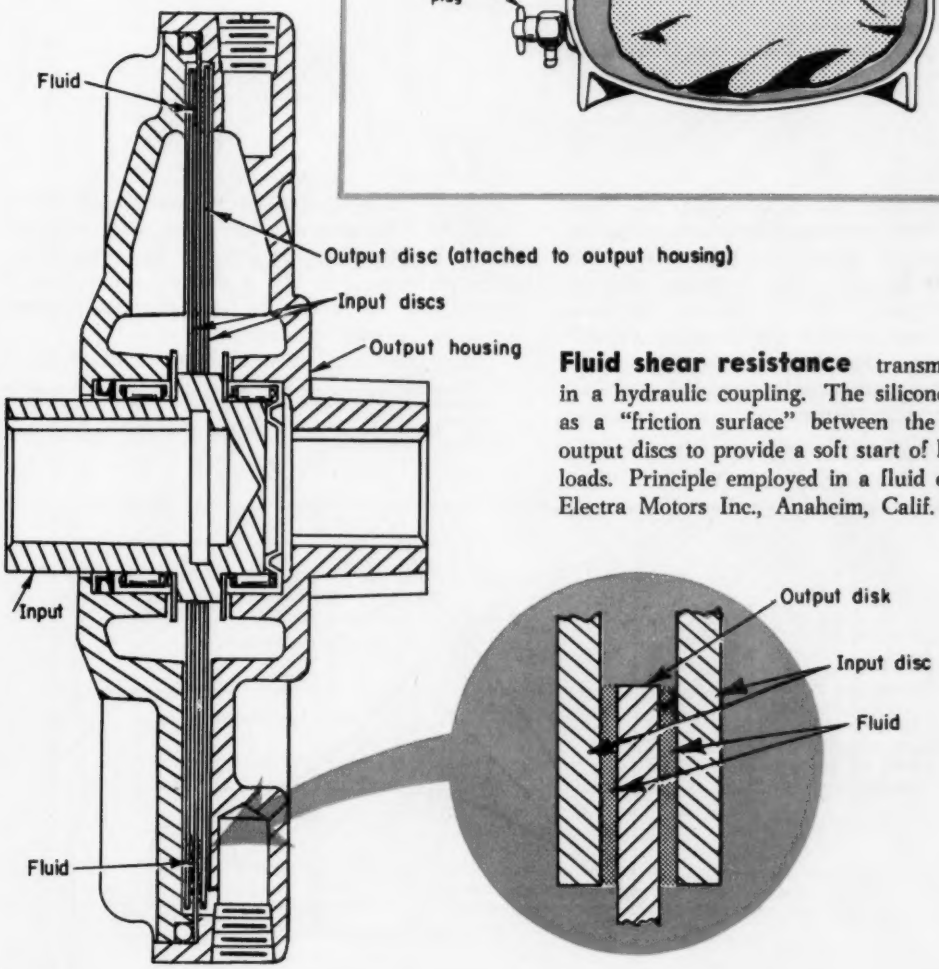
Fluid-powered poppet in a venturi valve opens and closes by energy of liquid being controlled. When the pilot valve is closed, upstream pressure holds the poppet valve on the seat. When the pilot valve is opened, the reduced pressure behind the poppet permits it to be opened by upstream pressure. Self-operating principle employed in a valve by Fox Valve Development Co., Verona, N. J.

Frictionless flexure-mounting of armature permits detection of excess vibration to actuate a safety cut-off switch. In the normal position, the adjusting spring partially balances the attraction of the main magnet. When the vibration inertia forces, acting on the mass of the armature, exceed a preset value, the armature is forced against the latching magnet. Principle employed in a vibration-detection unit by Aeronautical and Instrument Div., Robertshaw-Fulton Controls Co., Anaheim, Calif.



Fluid squeezes bag to provide pressure required to inject second fluid into primary stream. An orifice reduces the pressure of the primary stream below the pressure produced in the plastic bag. Principle employed in a liquid proportioner by Gustafson Mfg. Co. Inc., Minneapolis, Minn.





Fluid shear resistance transmits torque in a hydraulic coupling. The silicone fluid acts as a "friction surface" between the input and output discs to provide a soft start of high-inertia loads. Principle employed in a fluid coupling by Electra Motors Inc., Anaheim, Calif.

Virtually unchanged for over 25 years, roller-chain standards have recently been updated by chain manufacturers. Result: A big boost in rated speed and horsepower capabilities. Here's how to use the

New ROLLER-CHAIN HORSEPOWER RATINGS

J. F. PFRANK and **C. O. SUNDBERG**
Senior Engineer — Chief Engineer
Product Application & Research
Diamond Chain Co. Inc., Indianapolis, Ind.

IN RECENT years, many advances have been made in chain and sprocket design, materials, and lubrication techniques. However, roller-chain standards have remained relatively static for more than 25 years. Recent research by chain manufacturers has revealed the increased capabilities of available chain drives.

Speed and horsepower ratings in ASA Standard B29.1-1957 are very conservative. For maximum power transmission from chain drives, the Association of Roller and Silent Chain Manufacturers (ARSCM)* has proposed that speed and horsepower ratings be revised to be more in line with actual chain performance.† Fig. 1 shows a comparison of the old and new ratings for 1-in. pitch chain operating over 30-tooth sprockets.

The typical "tent" curve of the new ratings, Fig. 1

*The ARSCM has recently been dissolved. Its member companies are now members of the American Sprocket Chain Manufacturers Association (ASCMA).

†New ARSCM ratings will be submitted to ASA Sectional Committee B29 in September.

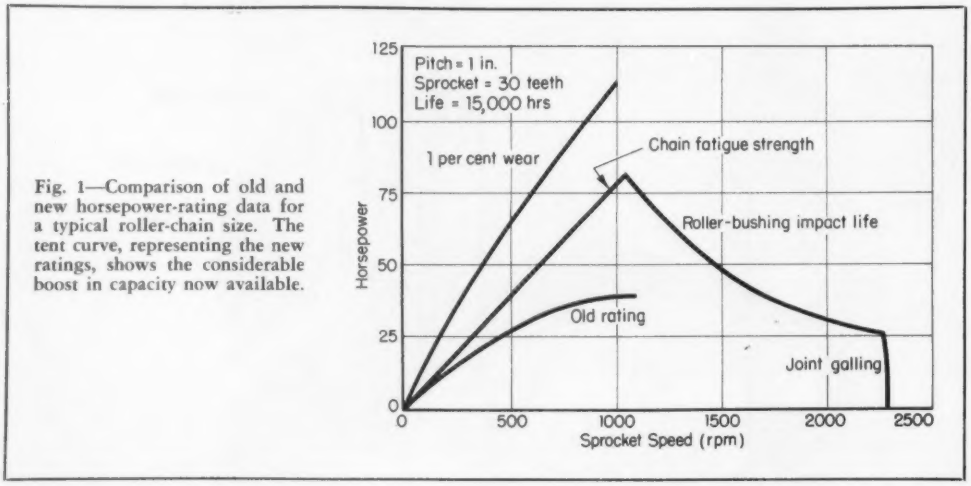


Fig. 1—Comparison of old and new horsepower-rating data for a typical roller-chain size. The tent curve, representing the new ratings, shows the considerable boost in capacity now available.

Circle 14-3 on Page 19 for extra copy.

and 2, illustrates not only the increased load and speed capacity provided, but also the basic characteristics of roller chain, as learned through industry-sponsored research. Tabular data shown in the new ratings for any given pitch of chain and number of teeth will, when plotted graphically, show the same general shape. Fatigue strength, impact life, wear life, and joint-galling parameters are outlined by these curves.

These new ratings offer reliable predictions of service life expectancy under continuous full-load operation. Ratings are for approximately 15,000 hours of service-life expectancy. According to recently completed industry-sponsored research at Arthur D. Little Inc., wear life, with recommended lubrication, will be satisfactory in most applications.

Tests have shown that during operation, lubricatcated chain joints act like journal bearings, with the formation of a hydrodynamic film of lubricant. The new horsepower ratings, based on these findings and a modified journal-bearing concept, take into account the load-supporting wedge of fluid lubricant which is formed during joint articulation. As in full journal bearings, the coefficient of friction or wear rate is influenced by viscosity of the fluid lubricant, by rotational speed, and by projected bearing pressure.

Effective use of the new ratings begins with careful consideration of application requirements. Chain drive selection can be readily made by applying appropriate service factors and multiple-strand factors to the input horsepower. But one pitch of

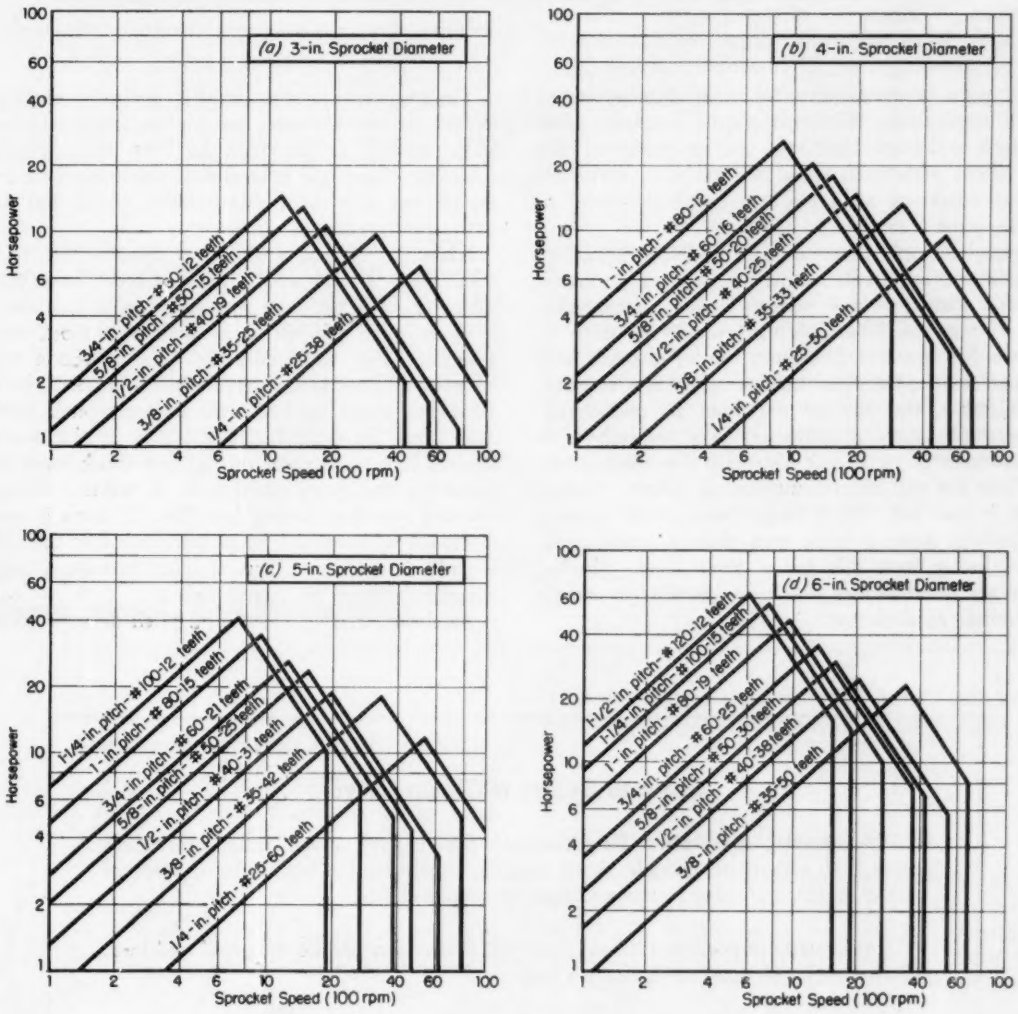


Fig. 2—Representative tent curves, showing new ratings for commonly used chain sizes. These curves are for single-strand chains. Since ratings are based on pitch diameter of the small sprocket, these charts are tied to space requirements in any given application.

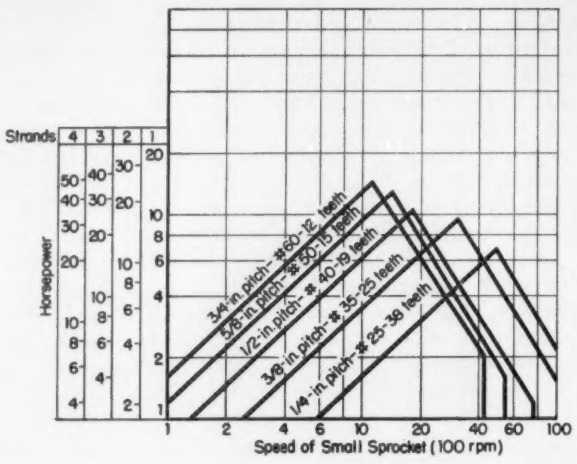

Strands 4 3 2 1
Horsepower
3/4-in. pitch- # 60- 12 teeth
5/8-in. pitch- # 50-15 teeth
1/2-in. pitch- # 40-19 teeth
3/8-in. pitch- # 35-25 teeth
1/4-in. pitch- # 25-38 teeth
Speed of Small Sprocket (100 rpm)

Fig. 3—Horsepower ratings for multiple-strand roller-chain drive with 3-in. sprocket diam.

chain may be more effective than another for a given application. For example, if a chain drive connects a 10-hp, 1800-rpm electric motor to the load shaft, with shaft speed = 900 rpm, there are several selections available, ranging from ½-in. to 1¼-in. pitch chain.

Several factors influence chain and sprocket selection. Space requirements may necessitate a certain sprocket diameter—and here, it is well to remember that ratings are based on the number of teeth in the smaller sprocket. Shaft size, center distance, and desired shaft speed ratio must be taken into account. In addition, the obvious must not be overlooked; for example, sprocket diameters vary not only with the number of teeth, but also with the chain pitch.

There are still other complicating factors. Among them is the fact that a large chain pitch, because it provides more bearing area than a small pitch, offers better wear life for a given load. Finally, there are those factors which are peculiar to certain individual applications.

The preceding discussion also applies to multiple-strand drives operating at higher loads. This is shown in Fig. 3. The chart, for 3-in. pitch diameter sprockets, shows the horsepower which can be transmitted not only with single-strand chain, but also with multiple-strand drives.

EXAMPLE: Select a chain to transmit 10 hp at 1800 rpm. If the small sprocket must have pitch diameter = 3 in., only one selection is available—a ½-in. pitch No. 40 chain with a 19-tooth small sprocket (Fig. 2*a*). Although this selection may be used as long as no overloads are imposed, better wear life could be had with a larger-pitch chain. Also, since drive conditions are close to the smaller chain's fatigue-strength rating, any shock loads imposed on the drive could lead to failure. Finally, when a sprocket having less than 25 teeth is used, it should be hardened for proper wear life; this adds slightly to the cost. Thus, if space permits, a larger sprocket should be considered.

As shown in Fig. 2*b*, a 4-in. pitch diameter offers

How to Select a Chain Drive

• **Consider Application Requirements:** Speed, load, space, ratio, lubrication come first. Evaluate possible shock loading, provisions for wear take-up, type of power source, and other factors necessary to make a choice.

• **Determine Possible Pitches:** Find which sizes can handle the speed and load. Charts similar to those in Fig. 2 are a help.

• **Make Final Selection:** Base the final choice on life requirements and costs. The ideal selection is that which does the job at minimum cost. Fig. 4 gives a general idea of wear-life/pitch relationships.

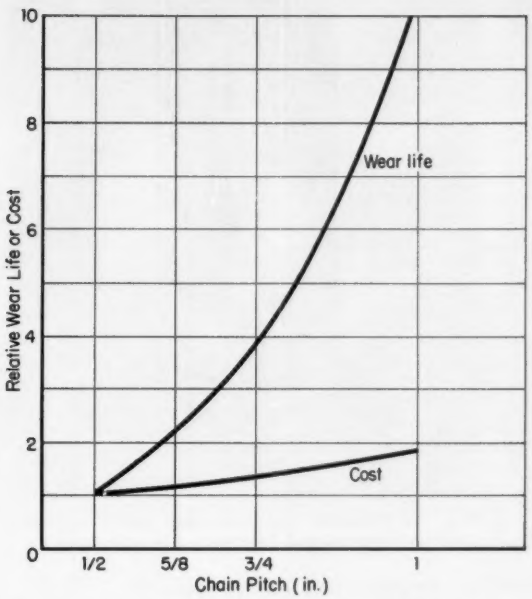


Fig. 4—Effect of chain pitch on relative wear life and costs for roller chains having equal center distance and sprocket diameters. Improvement in wear service life of the chain increases much more rapidly than does the cost.

three choices: A 25 tooth, ½-in. pitch, No. 40 chain, a 20-tooth, ⅝-in. pitch, No. 50 chain, or a 16-tooth, ¾-in. pitch, No. 60 chain. All three can handle the speed and load. However, the ½-in. pitch No. 40 chain is the most practical selection, since the drive conditions fall just under the peak of the chain's "tent" curve.

If space permits the use of larger pitch diameter sprockets, several other selections are possible, Fig. 2*c* and 2*d*. Again, the ½-in. pitch No. 40 chain seems ideal, since the intersection of the hp and rpm lines is almost directly under the peaks of the "tent" curves. But in this case, another factor influences selection—the type of lubrication required. Use of the 4-in. pitch diameter (25T-No. 40) sprockets shown in Fig. 2*b* permits oil bath lubrication, as indicated in the rating tables. The use of larger-diameter sprockets causes an increase in chain velocity and requires oil stream (pump) lubrication. Since this results in added cost, such a selection is less desirable. The type of lubrication needed may readily be checked by calculating chain velocity and comparing it with the limits which are given in the rating tables.

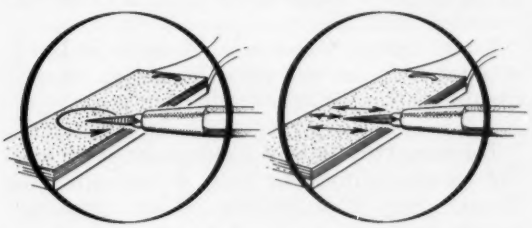
After load-carrying capabilities have been considered, relative wear life and drive costs should be examined. The new ratings are based on a maximum of 3 per cent increase in chain length due to joint wear in approximately 15,000 hours of service life. This is generally acceptable for most applications. However, there may be special conditions: Long center distances without adjustment to take up for wear; close case clearances; fixed centers; etc. These may make it necessary to provide greater wear resistance. In this case the relative wear life potential would have to be increased within economical bounds.

Fig. 4 shows the effect of chain pitch on relative wear life and costs, for roller chain drives having the same center distance and sprocket diameters. In general, the improvement in wear service life increases much more rapidly than drive costs. For example, a 100 per cent increase in wear life can be obtained at a 20 per cent increase in cost, simply by going from a ½-in. pitch No. 40 to a ⅝-in. pitch No. 50 drive. Of course, this increase in cost is not justified if wear service life is already adequate.

Tips and Techniques

Sharpening Drawing Pencils

The usual method of pointing a drawing pencil, by rolling the lead as it is drawn across the sandpaper pad, may result in excessive breakage during use. This can be avoided by drawing the lead axially along the sandpaper a few times as shown. The axial stress lines thus set up result in greatly extended pencil-point life.—R. C. GRABOWSKI, *General Motors Corp., Detroit, Mich.*



Lined Drawing Board

Vertical lines inked on the drawing board at 6-in. intervals can be a timesaver. They are especially useful for: 1. Arranging work on the drawing. 2. Centering a drawing on the board. 3. Determining the length of a tracing when roll stock is being used.—CHARLES W. BITTNER, *Precision Parts Co. Inc., Haddonfield, N. J.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, *Penton Bldg., Cleveland 13, O.*

Component layout and assembly techniques for

Preventing Electronic Hot Spots

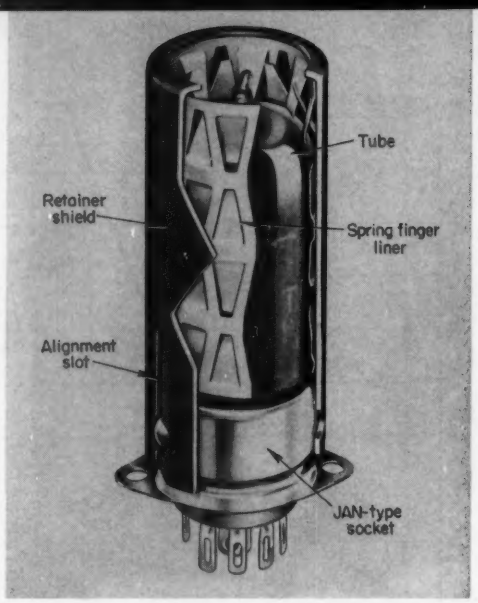


Fig. 1—Preferred miniature-tube shield. (Photo, courtesy International Electronic Research Corp.)

FRANK WILLIAM WOOD Jr.
Advanced Designs Inc.
Vienna, Va.

TROUBLESOME electronic equipment failures continue to occur even with all the emphasis that is being placed on reliability. Many of these failures are due to using parts that are not designed to do the job. When this usage is combined with poor layout of the electronic package, high failure rates are bound to occur. Solutions to the latter, and often less obvious, problem are the subject of this article.

Tube-Shields: Highly polished, loosely fitting shields of the JAN-S-28 type around electron tubes create heat zones in excess of manufacturers' ratings. High tube temperatures liberate gases inside tubes, resulting in arc-over between tube elements and shortened tube life.

An increase of 12 to 1 in useful tube life has been attained in tests using the shield and liner shown in Fig. 1 in place of the JAN-S-28 shield, which is no longer approved by most military agencies. Relative temperature variances are shown in Fig. 2.

The heat-dissipating shield of Fig. 3 is recommended for subminiature tubes. Mounting design for this type of shield should provide direct connection of shield base to a heat sink, Fig. 4.

Tubes having metal-base shields should be mounted with the base above the chassis for most effective cooling, Fig. 5*a*.

Transistor Heat-Sinks: A disadvantage of the small and remarkable transistor is its limited capacity to dissipate heat from its case without permanent damage.

Heat dissipators for transistors are available. They function by radiation and convection. Fig. 6 illustrates typical mountings that serve as heat dis-

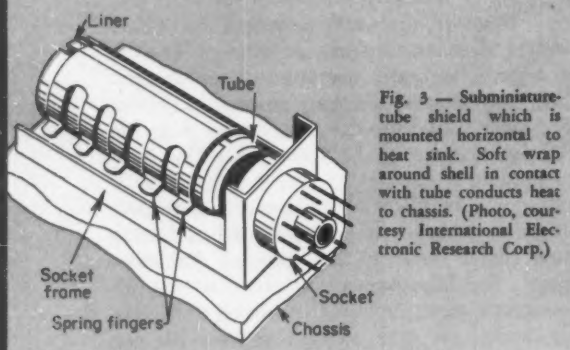


Fig. 3 — Subminiature-tube shield which is mounted horizontal to heat sink. Soft wrap around shell in contact with tube conducts heat to chassis. (Photo, courtesy International Electronic Research Corp.)

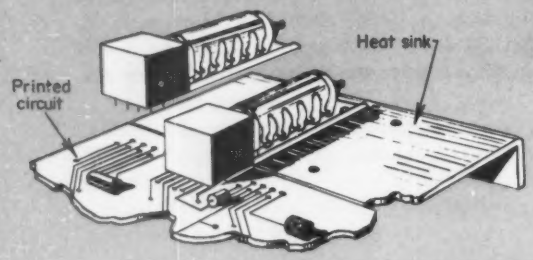


Fig. 4—Recommended mounting design for tube shield in Fig. 3. Auxiliary heat sink for preventing hot spot is mounted on printed wiring board. Circuit wiring is normally on opposite side of board. (Drawing, courtesy International Electronic Research Corp.)

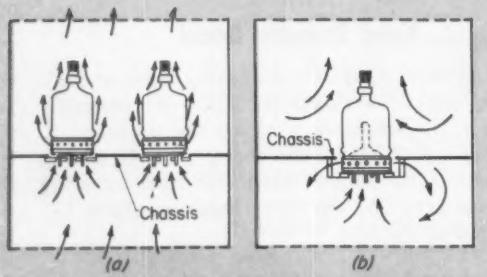
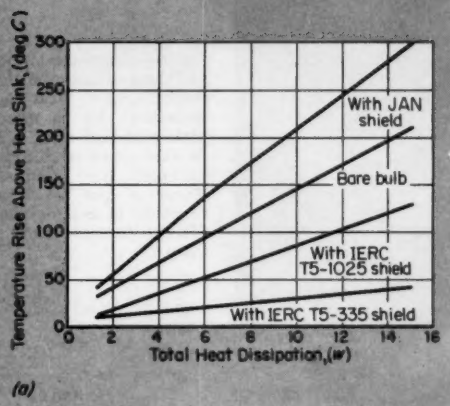


Fig. 5—Metal-base shell-tube mountings: *a*, Preferred design provides maximum cooling efficiency; *b*, recessed design blocks air circulation and prevents effective base cooling.

Circle 14-4 on Page 19 for extra copy.



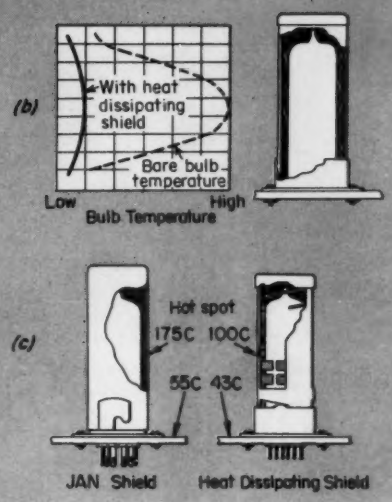


Fig. 2—Temperature variances: *a*, Electron tube (6005/6AQ5) with different types of shields; *b*, tube surface temperature gradient with and without heat-dissipating shield; *c*, chassis. (Drawings, courtesy International Electronic Research Corp.)

Military Design Requirements for Electronic Equipment Temperatures and Cooling

In view of the high operating temperature condition of equipment (and the subsequent deterioration of parts due to this condition) the various parts must be located properly.

Location of Parts: Because of the possible degradation caused by temperature due to the nonjudicious choice of parts, it is obviously undesirable to place many parts in the vicinity of items generating substantial heat, such as transformers and tubes. Attention should be directed to the cooling of cylindrically shaped parts by use of "chimney effect" by mounting in a vertical plane. Where parts are stacked, the heat gradient and subsequent "hot spot" of the upper stack(s) should be given careful consideration.

Enclosed Parts: No exposed parts, including the enclosure, of the equipment shall under any condition of operation achieve a temperature in excess of 60 C at any ambient temperature of 25 C. The temperature of front panels and operating controls shall not exceed 43 C.

Thermal System: It is important to design an integral thermal system into electronic equipment so that dissipated heat can be removed as efficiently as possible and with minimum heating of air and parts near heat sources. Such design must be accomplished early in the equipment development, concurrently with electronic design.

Precautions: All applications of parts in almost all types have limited maximum allowable temperature ratings above which the part cannot be operated without reducing seriously the useful and dependable life of the part due to deterioration of the electrical and other characteristics of the various materials comprising the completed* equipment. This deterioration caused by temperature may occur gradually or within a very short period following energizing of the completed equipment. Where parts have been applied in such manner as to impose temperature appreciable above the rated maximum permissible temperature, failure of the parts involved will occur often during preproduction inspection of the preproduction model.

Misapplication: Gradual deterioration of parts due to misapplication with resultant exposure to excessive temperature is more serious in that such deterioration is difficult to detect and is more likely to occur after the equipment has been placed in service. Four main factors contributing to the ultimate temperature imposed on the part are:

1. Local (hot spot) temperature rise due to the part involved being located (within the completed equipment) in close proximity to high heat-generating parts such as vacuum-tube rectifiers, power, and wire-wound resistors. Temperature rise for the part involved can be minimized by the careful placement of the parts which generate high heat or, where necessary, by the use of heat shields and reflectors.
2. The ambient temperature to which the equipment as a whole will be subjected.
3. The average temperature rise within the equipment due to heat dissipated by such parts as tubes, resistors, and transformers. In some equipment, it is necessary to limit temperature rise due to this factor by the use of some type of forced ventilation (blowers and fans).
4. Temperature rise within the part involved due to energy losses dissipated within the part.

Water Cooling: The following criteria define limits for application of water cooling: Total heat dissipation exceeding 5,000 w; unit heat dissipation exceeding 10 w per sq ft of enclosure surface area.

sipators for one or for a group of transistors.

Available also for transistor cooling are washers that insulate electrically, yet act as high thermal conductors that can be placed between a transistor and the chassis, Fig. 7. A thin coat of silicone grease should be used on both sides of the washer to provide an unbroken heat path through all the parts.

High-Wattage Resistors: Just because a resistor is shown on a schematic diagram coupled to a paper capacitor and a germanium diode does not mean it can be mounted side by side with these

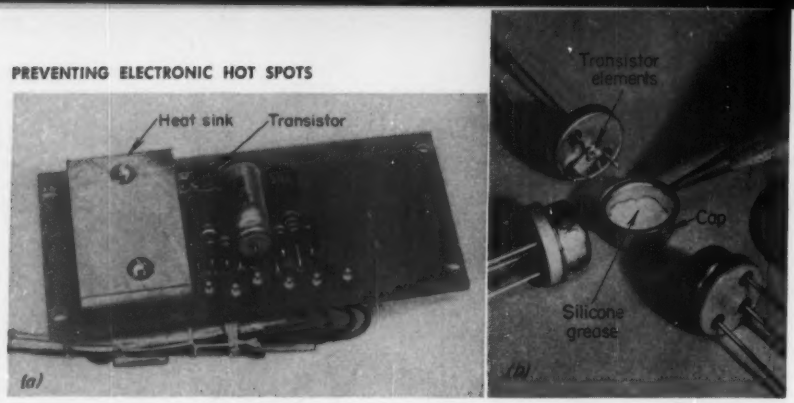


Fig. 6—Combination mountings and heat dissipators for transistors: *a*, Heat-conducting transistor clip is attached to plate-type heat sink; *b*, friction-fit case contains silicone grease heat-path from transistor elements to case which must be mounted to external heat sink. (Photo, courtesy Dow Corning Corp.)

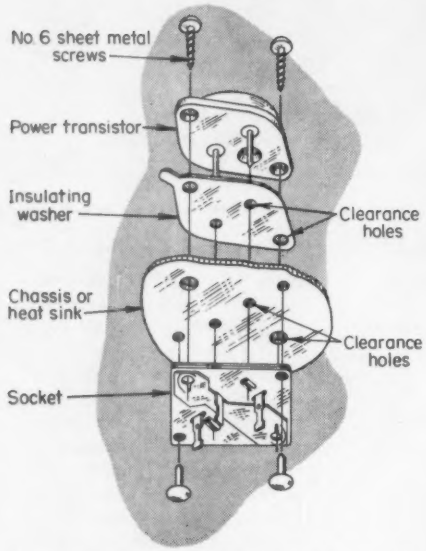


Fig. 7—Sandwiched insulating washer which serves as heat conductor. Silicone grease coating on both sides of washer provides unbroken heat path from power transistor to chassis.

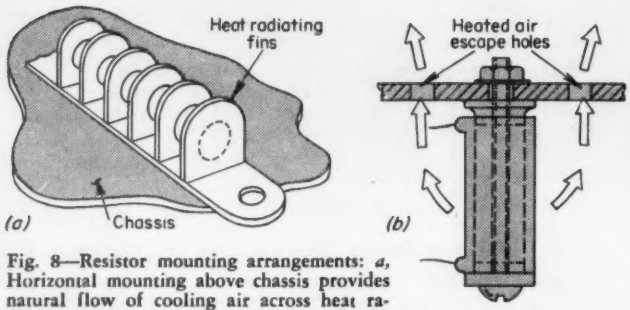


Fig. 8—Resistor mounting arrangements: *a*, Horizontal mounting above chassis provides natural flow of cooling air across heat radiating fins on resistor; *b*, vertical mounting under chassis requires escape holes for heated air.

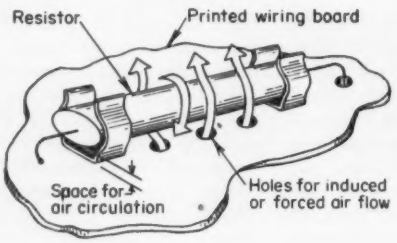


Fig. 9 — Mounting clips, either single or in pairs, with air space between high-wattage resistor and phenolic or epoxy component boards.

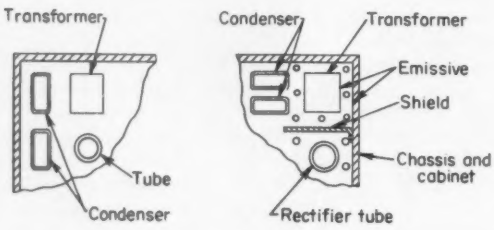


Fig. 10—Tube and transformer location: *a*, Inefficient layout for heat dissipation; *b*, improved layout which utilizes cabinet to dissipate heat directly.

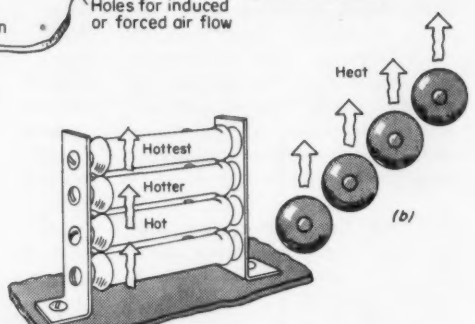


Fig. 11—Stacked resistor arrangements: *a*, Straight stacking increases temperature gradient at top; *b*, oblique stacking equalizes temperature distribution.

components in the actual equipment. Resistors mounted on the chassis in the manner of Fig. 8 should be used to reduce the ambient temperature in the resistor area.

Where these arrangements are not practical and the resistor must be mounted on a component board, fuse-type clips that will permit air circulation around the resistor may be used, Fig. 9. The resistor should be oriented on the board so that it is not below a heat-sensitive component.

Component Location: Heat-dissipating components should be located on the chassis so that they are not boxed in by components of the nonheat-dissipating variety. The location of the tube and transformer in Fig. 10*a* not only places both of these components in danger of overheating but also exposes the heat-sensitive capacitors to their full heat radiation. A better layout of these components is shown in Fig. 10*b*. Here, a shield has been placed between the main heat-radiating source, which is

Derating Factors for Ambient Temperatures Above 35 C (95 F)

Ambient Temperature	Maximum rms Reverse Voltage (Per cent of normal at 35 C)	Maximum dc Amperes (Per cent of normal at 35 C)
40 C (104 F)	100	84
45 C (113 F)	100	63
50 C (122 F)	100	47
	80	63
55 C (131 F)	80	47
	60	63
60 C (140 F)	80	30
	60	47
65 C (149 F)	60	30
70 C (158 F)	60	10

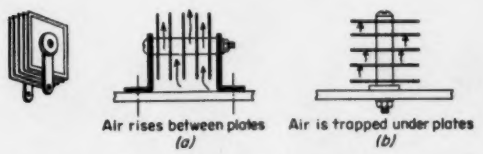


Fig. 12—Selenium-rectifier mounting: *a*, Preferred arrangement has edges of plates facing air flow in forced-air cooling; *b*, vertical mounting traps air under plates and should be avoided. When the rectifier is operated in ambient temperatures exceeding 35 C, current and voltage output ratings should be modified by factors shown in the table. For 50, 55, and 60 C, two sets of values are given, either one of which may be used depending on the most favorable design considerations.

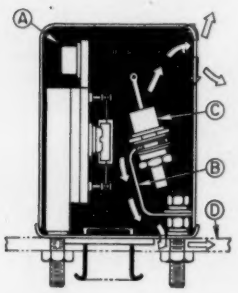


Fig. 13—Methods of dissipating heat in encapsulated assemblies: Aluminum oxide powder (A) provides encapsulating material of high thermal conductivity; aluminum bracket (B) conducts heat from power diode (C) to mounting stud, and then to heat sink chassis (D).

the rectifier tube, and the other components. Both the tube and the transformer are adjacent to the cabinet with its relatively large area for conducting heat from the inside of the cabinet and radiating it to outside air. Perforations in the chassis around the tube and transformer induce air-flow cooling.

Stacked Components: Hot spots can be introduced when heat-dissipating components are stacked without regard to the increasing temperature gradient toward the top of the stack.

In electronic-package designs where components are stacked, resistors can be arranged as in Fig. 11*b* to equalize temperature rises. Selenium rectifiers can be arranged as in Fig. 12*a*.

Encapsulated Assemblies: Special design techniques must be used to provide a heat path between the heat-dissipating components within an encapsulated unit and the air outside. Failure to do so will result either in a high failure rate of the components or a split in the encapsulation from thermal expansion. Two methods can be used to prevent hot spots in encapsulated units:

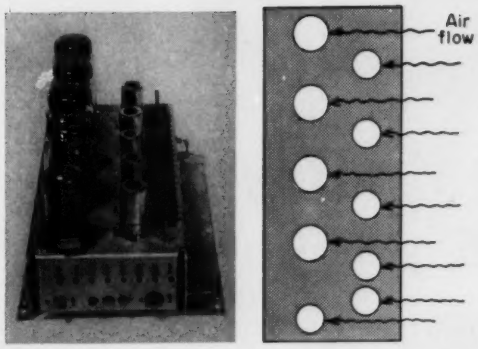


Fig. 14—Tubes positioned to receive maximum cooling by forced air flow. (Photo, courtesy Servonics Inc.)

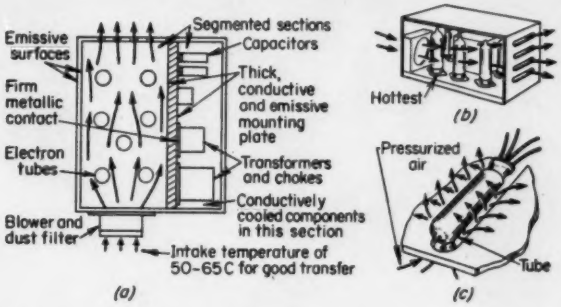


Fig. 15—Methods of forced-air cooling: *a*, Forced in-out air flow; *b*, cross-flow; *c*, turbulent air flow for extreme hot spots.

1. Use encapsulating material of high heat conductivity.
2. Use brackets to conduct heat from hot components to mounting studs on the encapsulated assembly.

Both methods are illustrated in Fig. 13. An aluminum-oxide powder is used as a loose encapsulating material. Aluminum oxide powder is an excellent heat conductor and also a good electrical insulator.

This powder method is applicable only when a can is used to house the assembly. The unit is assembled and the aluminum oxide is poured through a filler hole in the can, which is then plugged.

Fig. 13 also shows a power silicon diode mounted directly upon an aluminum bracket that in turn is attached to a mounting stud of the unit. To prevent premature damage in testing, units encapsulated this way should carry a label stating that connection to an external heat sink is required before operating.

Forced Air Flow: When adequate cooling cannot be obtained by heat dissipators, induced air flow, radiation shields, or conduction, then forced air-cooling must be used.

Efficient cooling by forced air requires more than selecting the largest blower that will fit in the particular cabinet. Component layout must be designed to get maximum cooling with minimum blockage of air flow. The chassis assembly of Fig. 14 illustrates a layout in which all tubes receive maximum cooling by forced air. Fig. 15 illustrates other layouts for cooling by forced air.

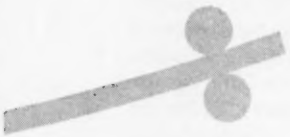
designing flexible beam suspensions *with safe vibration characteristics*

1 **The problem . . . design approach . . . resonant-frequency charts**

2 Precalculated coefficients . . . solution methods . . . design examples

DARRELL A. FROHRIB
Lecturer, Institute of Technology
University of Minnesota
Minneapolis, Minn.
and
Consultant, Stress and Dynamics Analysis Group
Remington Rand Univac
Div. of Sperry Rand Corp.
St. Paul, Minn.

Circle 14-5 on Page 19 for extra copy.



MOUNTING systems for vibration environments often consist of an assembly or component suspended on a flexible beam-like support. In such systems, amplification of vibratory motions transmitted through the support members can create serious operating problems, such as stress failures, impacting of close-tolerance mechanical parts, and spurious electrical outputs from electro-mechanical devices.

Even if such possibilities are recognized in design, a satisfactory solution may not always be possible at the drawing-board stage. Dynamic performance of beam-suspended elements is often difficult to predict quantitatively, because a complex mechanical arrangement, with varying conditions of flexibility and mass distribution is involved. Inherent in such situations are a number of uncoupled or coupled resonant frequencies which can produce amplification when excited by a vibrational environment.[1]

From a design view, a useful solution would be a numerical correlation of the various parameters involved in a vibration analysis, with a clear indication of their influence upon the system's dynamic response. This information would provide freedom in design to rapidly select satisfactory geometric shape, mass, and stiffness characteristics to meet operating requirements. However, a general correlation of this type often represents an impractical amount of high-accuracy calculation by conventional procedures, and may never be attempted. The use of current techniques in automatic electronic computation can be a powerful aid in such efforts.

[1]References are tabulated at end of article.

This article presents the results of a general analysis of the dynamics of beam-suspended elements, using such computation techniques. Results are numerically correlated to indicate important trends and to permit rapid selection of design parameters.

Application of these results to various design situations will be discussed in a later article.

• The Problem

In many design situations, the mechanical member supporting a component or assembly approximates a slender beam. This beam is often much more flexible than the supported item. Examples of this condition are: Electrical transformer on sheet-metal chassis, Fig. 1*a*; compact electronic cabinet attached to long support members, Fig. 1*b*; and rigid machine chassis on flexible foundation members. It is not uncommon for the suspended item to comprise 80 to 90 per cent of the total weight of the assembly.

If the beam-like foundation mass distribution is excluded, this wide class of designs contains certain resonant frequencies which are responsible for large oscillatory deflections of the suspension in a dynamic environment. Inspection of the motion of the sus-

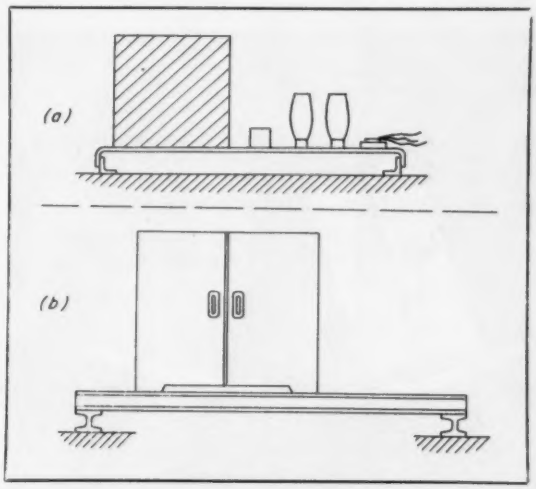


Fig. 1—Typical flexible beam suspensions: *a*, Heavy transformer on sheet-metal chassis; *b*, computer cabinet fixed to long support members. In the transformer suspension, *a*, other lighter weight components will have little effect upon the lower transverse-bending resonance.

pended element reveals two simultaneous events which are incurred by deflection of the foundation member, Fig. 2:

1. A rotational motion of the mass associated with the slope of the suspension in the region of the mounted element.
2. A transverse translatory displacement of the center of gravity of the suspended mass.

These two motions, or degrees of freedom, are interrelated through the flexibility of the beam-like suspension, and produce two coupled resonant frequencies in the system. This coupling is influenced by both the position of the suspended item, and the number of support points in the suspension. The two resonances are also dependent upon the translatory and rotary-inertia magnitudes of the suspended item and, hence, are related to its mass distribution and geometric shape.

From a design view, primary concern with these resonances lies in the associated dynamic deflections resulting under operational conditions. Steady-state study of these deflections introduces two additional variables into the analysis: 1. The relationship between the input frequency and the two resonant frequencies. 2. The effect of exciting each end of the suspension at the same frequency but with different amplitudes of motion

An additional variable, which has not been included in this analysis, is the damping inherent within the vibrating system. It influences deflection amplitudes, particularly near resonance. However, in systems composed essentially of tightly secured metallic parts the amount of damping is frequently quite nominal, often not exceeding 5 per cent of the equivalent critical viscous damping.[2] Because of this negligible effect, dynamic excitation usually must be prevented by designing the assembly to contain resonances out of the range of the input frequency. However, current progress in the use of damping materials and techniques holds promise for solutions to this problem other than detuning, which is considered here.

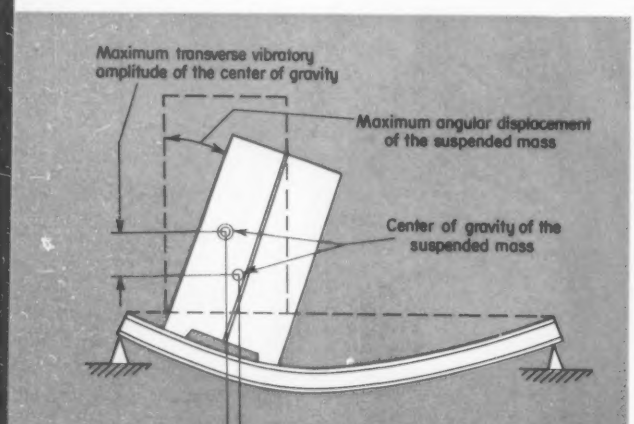

Maximum transverse vibratory amplitude of the center of gravity
Maximum angular displacement of the suspended mass
Center of gravity of the suspended mass
Maximum axial vibratory amplitude of the center of gravity

Fig. 2—Typical flexible-beam suspension in maximum deflected position produced by vibratory motion. This combination motion is characteristic of a first (lowest) mode resonance.

• Design Analysis

The general type of mechanical system dealt with here is shown in Fig. 3. This system contains certain geometric size, shape, and position variables, as well as parameters for flexibility and mass. Certain dynamic properties of such systems, dependent upon the geometry of the assembly, are the subject of this article.

The geometric variables of the system are defined nondimensionally. The position variable ξ (see Nomenclature) represents the position of the suspended mass relative to one end of the beam, and the variables κ and η represent both the size and shape, respectively, of the suspended element. This element is treated as a body of uniform mass distribution, since many mechanical devices can be approximated by this assumption.

In recognition of the tendency to minimize the amount of material and attachment hardware within

Nomenclature

a = Base dimension of suspended item (Fig. 3), in.
b = Height dimension of suspended item (Fig. 3), in.
E = Modulus of elasticity of beam material, psi
I = Area moment of inertia of beam cross section about neutral axis, in.^{4}
I_M = Rotary mass-moment of inertia of suspended item about axis through center of gravity, lb-in.-sec^2
l = Beam span between support points (Fig. 3), in.
M = $W/386$ = Mass of suspended item, lb-sec^2/in.
t = Time, sec
W = Weight of suspended item, lb
x = Distance from left beam support point (Fig 3), in.
Y = Amplitude, in.
y = $Y \sin \omega t$ = Displacement, in.
α = Influence coefficient (Table 1), in./lb.
β = Impedance coefficient (Table 1)
κ = a/l = Base size factor (Fig. 3)
η = b/a = Shape factor (Fig. 3)
ξ = x/l = Position factor (Fig. 3)
ω = Input frequency to system, rad/sec
ω_n = First mode resonance of beam support under the influence of its own weight, rad/sec
ω_{n1}, ω_{n2} = First and second mode resonant frequencies, respectively, of the system, rad/sec

Subscripts:
CG = Center of gravity of suspended element
$E1$, $E2$ = Left and right beam-support points, respectively
$R1$, $R2$ = Left and right support points, respectively, for suspended item

a design, a two-point attachment has been used between the rigid mass and the foundation. This arrangement provides one of the more flexible mountings involving rigid point supports. Inclusion of additional intermediate supports may be expected to raise the two resonant frequencies obtained in this analysis. However, for small values of ratio κ, the effect of intermediate mass supports will not appreciably alter the response values predicted.

Simple foundation supports, which are free of horizontal constraint, are used here for two reasons:

1. The simply supported arrangement is representative of a large class of systems, because the majority of

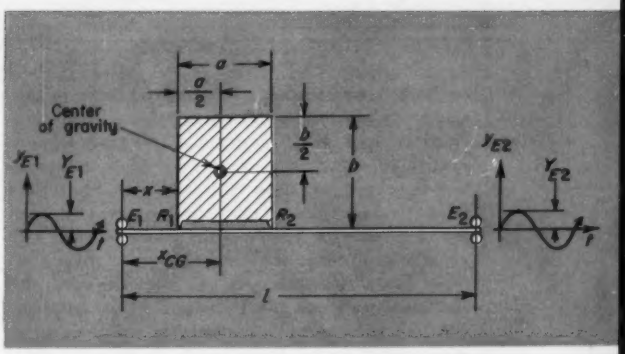


Fig. 3 — General shape, size, and position relationships for dynamic analysis of flexible beam suspensions.

Table 1—Basic Mathematical Relationships

Differential Equations of Steady-State Vibratory Motion

$$\frac{d^2y_{R1}}{dt^2} + \beta_2 y_{R1} = \beta_4 y_{R2} - \frac{d^2y_E}{dt^2} \quad (1)$$

$$\frac{d^2y_{R2}}{dt^2} + \beta_1 y_{R2} = \beta_3 y_{R1} - \frac{d^2y_E}{dt^2} \quad (2)$$

where $y_{E1} = y_{E2} = y_E$ (symmetrical inputs) and

$$\beta_1 = q\left[\alpha_1\left(\frac{2}{M} + \frac{a^2}{2I_M}\right) - \alpha_2\left(\frac{2}{M} - \frac{a^2}{2I_M}\right)\right] \quad (3)$$

$$\beta_2 = q\left[\alpha_4\left(\frac{2}{M} + \frac{a^2}{2I_M}\right) - \alpha_3\left(\frac{2}{M} - \frac{a^2}{2I_M}\right)\right] \quad (4)$$

$$\beta_3 = q\left[\alpha_3\left(\frac{2}{M} + \frac{a^2}{2I_M}\right) - \alpha_4\left(\frac{2}{M} - \frac{a^2}{2I_M}\right)\right] \quad (5)$$

$$\beta_4 = q\left[\alpha_2\left(\frac{2}{M} + \frac{a^2}{2I_M}\right) - \alpha_1\left(\frac{2}{M} - \frac{a^2}{2I_M}\right)\right] \quad (6)$$

$$q = \frac{1}{2(\alpha_1\alpha_4 - \alpha_2\alpha_3)} \quad (7)$$

$$\alpha_1 = \frac{\xi^2(1 - 2\xi + \xi^2)}{3} \quad (8)$$

$$\alpha_2 = \alpha_3 = \frac{\xi(1 - \xi - \kappa)[2\xi(1 - \xi - \kappa) + \kappa(2 - \kappa)]}{6} \quad (9)$$

$$\alpha_4 = \frac{(\xi + \kappa)^2[(1 - \xi)^2 + \kappa(\kappa + 2\xi - 2)]}{3} \quad (10)$$

Rotary Moment of Inertia

$$I_M = \frac{M(a^2 + b^2)}{12} \quad (11)$$

Resonant Frequencies

$$\omega_{n1}^2 = \left\{\frac{(\beta_1 + \beta_2) - [(\beta_1 + \beta_2)^2 - 4(\beta_1\beta_2 - \beta_3\beta_4)]^{1/2}}{2}\right\} \quad (12.1)$$

$$\omega_{n2}^2 = \left\{\frac{(\beta_1 + \beta_2) + [(\beta_1 + \beta_2)^2 - 4(\beta_1\beta_2 - \beta_3\beta_4)]^{1/2}}{2}\right\} \quad (12.2)$$

Vibratory Amplitudes

$$\frac{Y_{R1}}{Y_E} = \frac{\omega^2[\omega^2 - (\beta_1 + \beta_4)]}{-\omega^4 + \omega^2(\beta_1 + \beta_2) - (\beta_1\beta_2 - \beta_3\beta_4)} \quad (13)$$

$$\frac{Y_{R2}}{Y_E} = \frac{\omega^2[\omega^2 - (\beta_2 + \beta_3)]}{-\omega^4 + \omega^2(\beta_1 + \beta_2) - (\beta_1\beta_2 - \beta_3\beta_4)} \quad (14)$$

$$Y_{CG} = Y_E + \frac{Y_{R1} + Y_{R2}}{2} \quad (15)$$

mechanical supports are not sufficiently rigid to provide the equivalent of a cantilevered end fixity.

2. Freedom from axial constraint is necessary if this mechanical system is to contain only two resonances. Supports which sustain a horizontal force introduce a third vibration mode. This mode is incurred by "forcing" the center of gravity of the suspended item with an axial component of motion. However, when compared to the two resonances previously discussed, this additional resonance is high enough in the frequency spectrum to be quite unimportant in design except in very unusual cases. Consequently, it has been eliminated from the analysis by allowing no axial foundation constraint.

The equations on which this analysis is based are given in Table 1. Equations 1 and 2 are the differential equations which define the steady-state vibratory motions of the suspended item. The various coefficients and parameters are defined in Nomenclature, Fig. 3, and Equations 3 through 11. Use of the influence coefficients, α (Equations 8, 9, 10), has been covered by others.[3]

Equations 1 through 7 in Table 1 apply to mechanisms with centers of gravity oriented in the geometric center of the suspended item. Furthermore, if the suspended item can be assumed to be a uniformly dense rectangular element, the equations can be simplified by the introduction of the rotary moment of inertia, Equation 11.

For ease of calculation, Equations 3 through 7 can be simplified algebraically into expressions involving the ratios ξ, κ, η, and $EI/(Ml^3)$. Various design situations then can be investigated by simply substituting the appropriate values for the ratios into these expressions. When such calculations are performed for a representative range of geometric parameters ξ, κ, and η, valuable design information is obtained. From these data, two solutions can be obtained: 1. The two resonant frequencies of a design can be predicted when suitable geometric size and shape characteristics have been defined. 2. A suitable set of design dimensions can be established to remove the resonant conditions far enough from operating (input) frequencies to prevent excessive excitation.

The two resonant frequencies can be calculated directly from Equations 12.1 and 12.2, Table 1. These frequencies could also be determined by calculation of the deflections Y_{R1} and Y_{R2} for various input frequencies. These deflections have infinite amplitudes when the undamped system is vibrated at resonance,

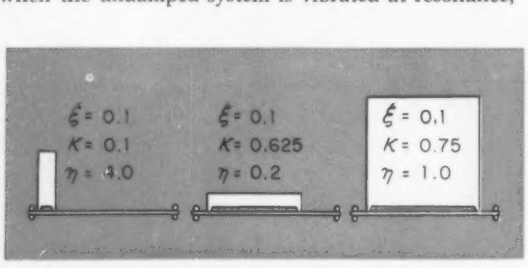


Fig. 4—Typical suspension systems covered by completed data.

and such trends in the computed results identify the frequencies. This information, as well as the vibratory displacements produced when the system is vibrated at any input frequency, can be obtained from Equations 13 through 15 of Table 1.

Equations 12.1 through 14 are organized to speed design calculations. The resonance characteristics have been numerically solved for 186 separate design situations, using a digital computer (Univac Scientific 1103A). Typical mass and suspension systems covered by these calculations are shown in Fig. 4. This range of data allows the designer to predict the steady-state vibrational effects produced by varying a system in several ways. The remainder of this article, and Part 2, will be devoted to a discussion of the response results, and where and how they can be used in the solution of design problems.

• Vibratory Response Data

Resonant frequency data obtained from the computed results are plotted in Fig. 5 through 10. Each chart corresponds to a specific value of κ. Individual plots for determining first and second-mode resonant frequencies are provided for six values of η on each chart. The vertical dashed lines are the asymptotes for the plots in each resonance range.

These charts are divided at $(x_{CG}/l) = 0.5$, because a given set of κ and η values produces two identical sets of resonant frequencies. These identical frequencies correspond to mirror locations of the suspended mass on the support member. In Fig. 3, these mirror locations are defined by $\xi = x/l$ and $\xi = 1 - [(x + a)/l]$. Thus, the families of resonance curves are symmetrical about $(x_{CG}/l) = 0.5$, and only one-half of the lower resonance family, $-0.5 \leqq (x_{CG}/l) \leqq 0.5$, and one-half of the upper family, $0.5 \leqq (x_{CG}/l) \leqq 1$, are shown.

The minimum (negative) limit for the lower resonance family has particular significance. The condition leading to a negative value of x_{CG}/l is demonstrated in Fig. 11. The plots for the lower resonance family have been extended to cover this situation where one end of the suspended item rests on a solid foundation at the end of the beam. Thus, these plots represent a complete set of resonance information for all dynamic conditions encountered as the suspended item moves progressively from the extreme left position (both support points off the beam) to positions with first one and then both supports on the beam. As this progressive movement to the right continues, the suspended item finally reaches the "mirror" situation at $(x_{CG}/l) = 0.5$ where frequency values begin to repeat. For each family of lower resonance plots the exact range covered is given by $-(\kappa/2) \leqq (x_{CG}/l) \leqq 0.5$ The second-mode plots have no definition under such circumstance and, consequently, have not been extended.

The charts can be used in two ways: 1. To calculate the resonant frequencies (ω_{n1}, ω_{n2}) for a specific design. 2. To determine qualitatively the influence of design changes upon the resonances expected within a mechanism.

The procedure for determining the resonant fre-

quencies for a specific suspension system is:

1. Calculate the flexural rigidity, *EI*, of the foundation.[4] In the analysis presented here, axial uniformity of the foundation has been assumed. However, minor variations, due to such features as keyways and other discontinuities, will have little effect upon this prediction, and can be disregarded.
2. Determine the first mode resonant frequency from the charts. The charts in Fig. 5 through 10 represent six practical design situations with different base size factors, $\kappa = a/l$.

If the design under analysis conforms approximately to one of the selected κ values, the corresponding chart can be used directly. The first mode resonance is obtained by using the appropriate plot for $\eta = b/a$ on the left side of the chart and locating the point corresponding to the position of the center of gravity (x_{CG}/l) of the suspended item on the beam supports. Note that $(x_{CG}/l) = \xi + (\kappa/2)$. From the ordinate of the point located on the curve, the first mode resonance, ω_{n1} can be calculated.

For example, assume a design situation where $\kappa = 0.5$,

Resonant Frequencies

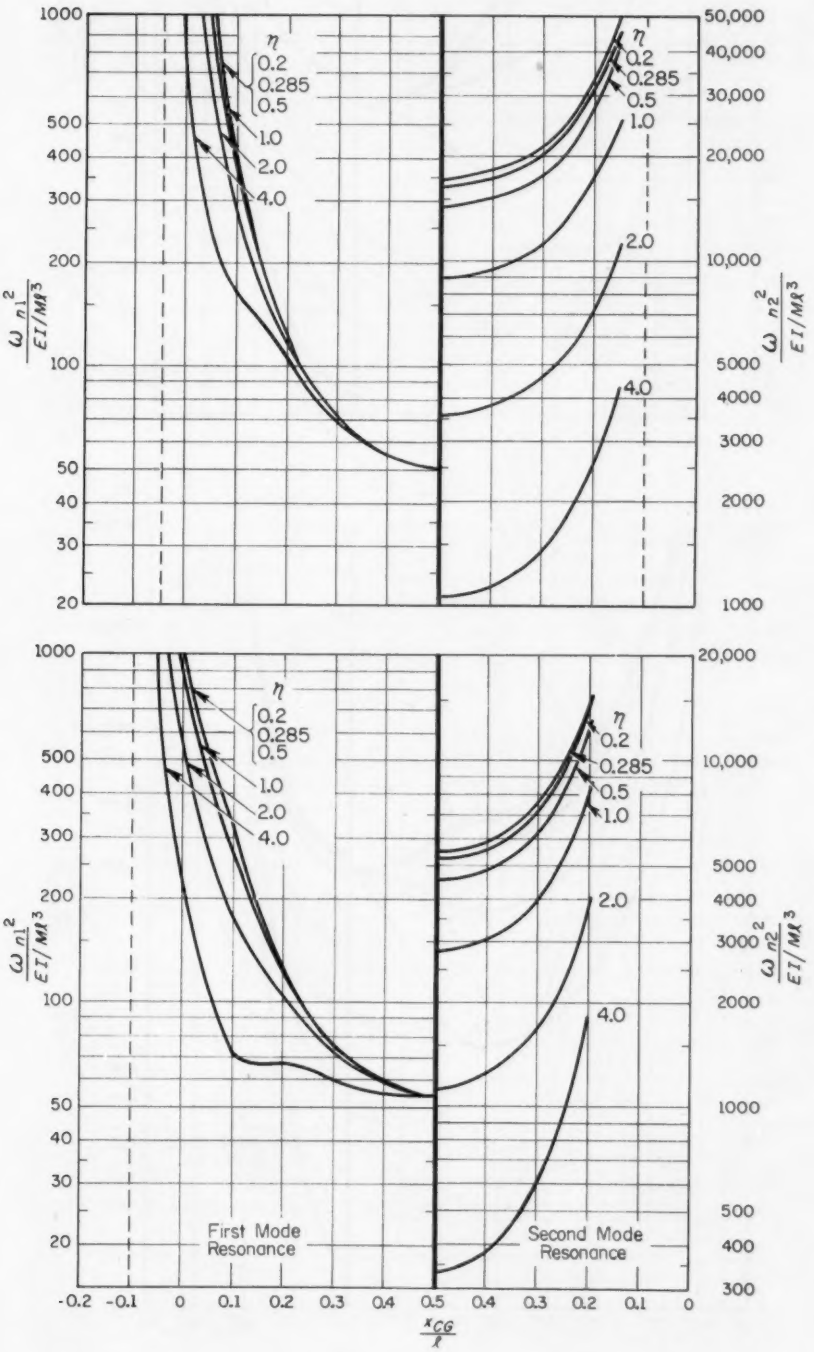


Fig. 5 —$\kappa = 0.1$

Fig. 6 —$\kappa = 0.2$

Resonant Frequencies

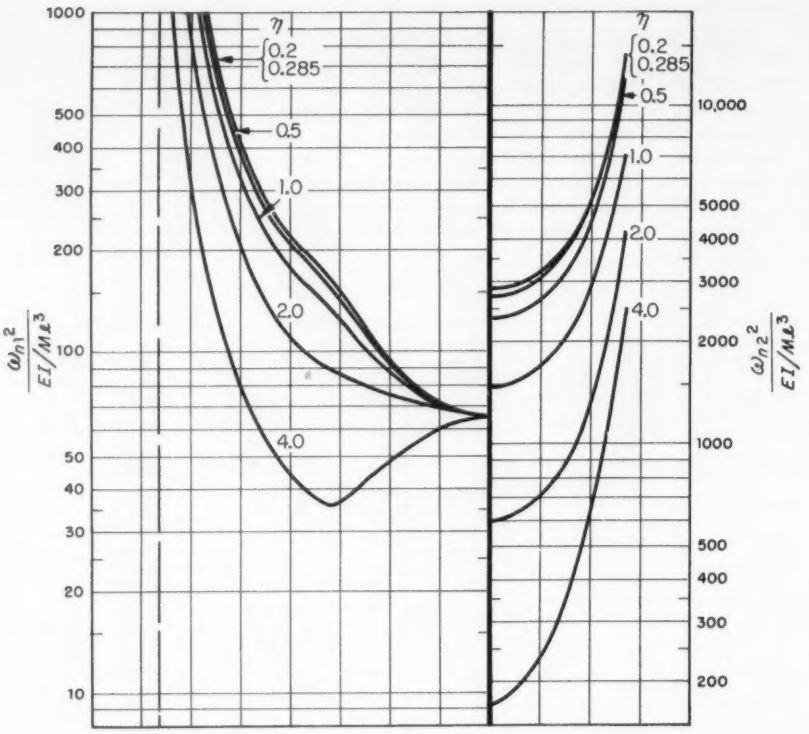


Fig. 7 —κ=0.333

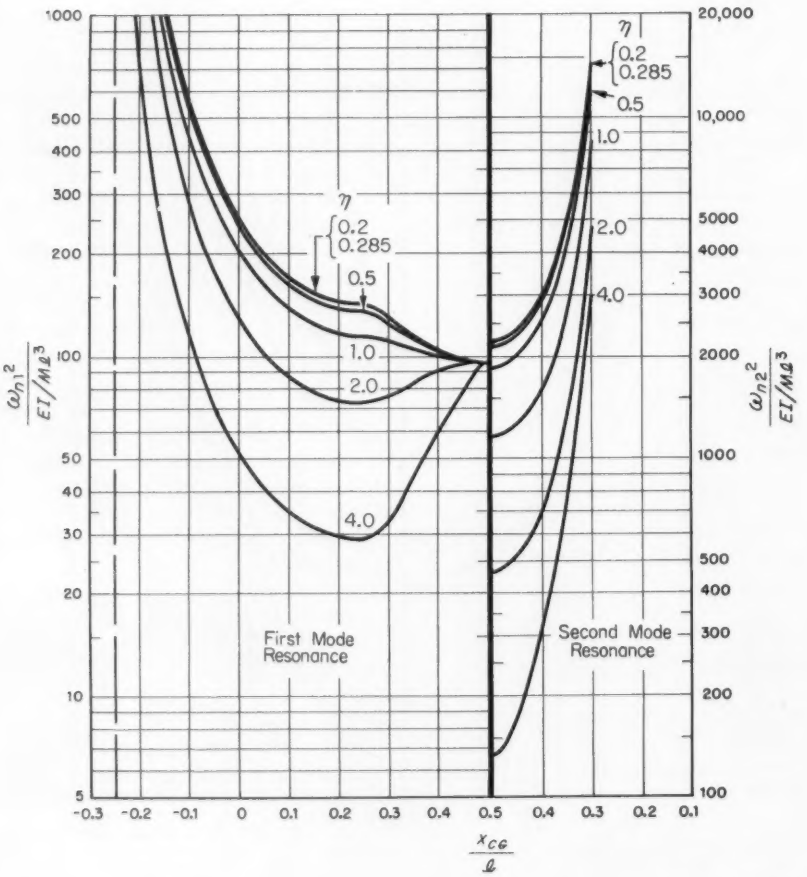


Fig. 8 —κ=0.5

$\eta = 1$, and $(x_{cg}/l) = 0.28$. From Fig. 8,

$$\frac{\omega_{n1}^2}{EI/Ml^3} = 110$$

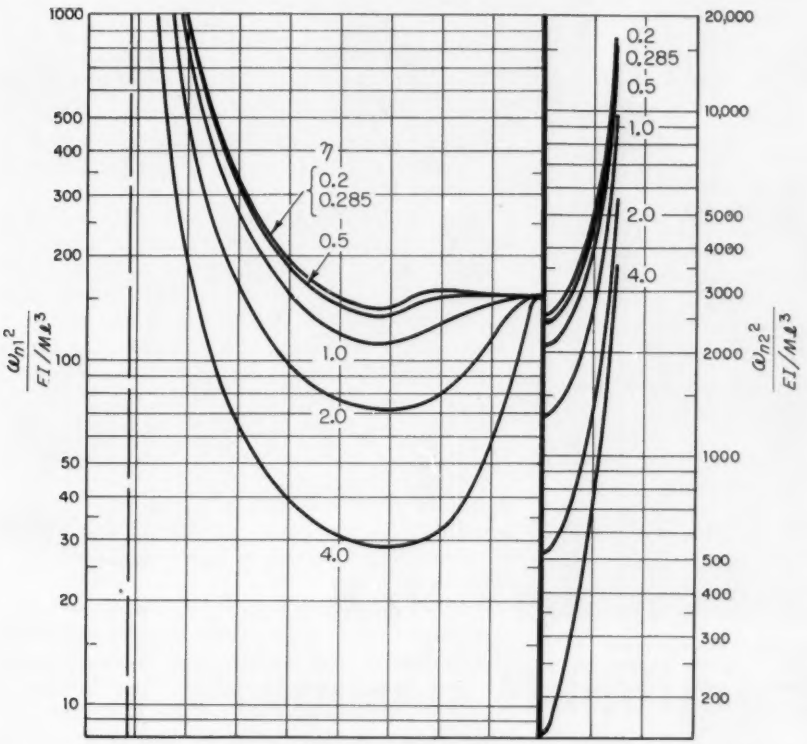
Thus, the first mode resonant frequency is

$$\omega_{n1} = \left(\frac{110\,EI}{Ml^3}\right)^{1/2}$$

3. Determine the second mode resonant frequency. Procedure is the same as for the first-mode resonance except the right side of the chart is used.

At this stage, effect of foundation weight on the first-mode resonant frequency determined from the charts should be checked. Details of this procedure will be discussed in the second article.

If a design situation falls between the selected κ values for the charts, the frequency values can be found with reasonable accuracy by interpolation.



Resonant Frequencies

Fig. 9 —$\kappa = 0.625$

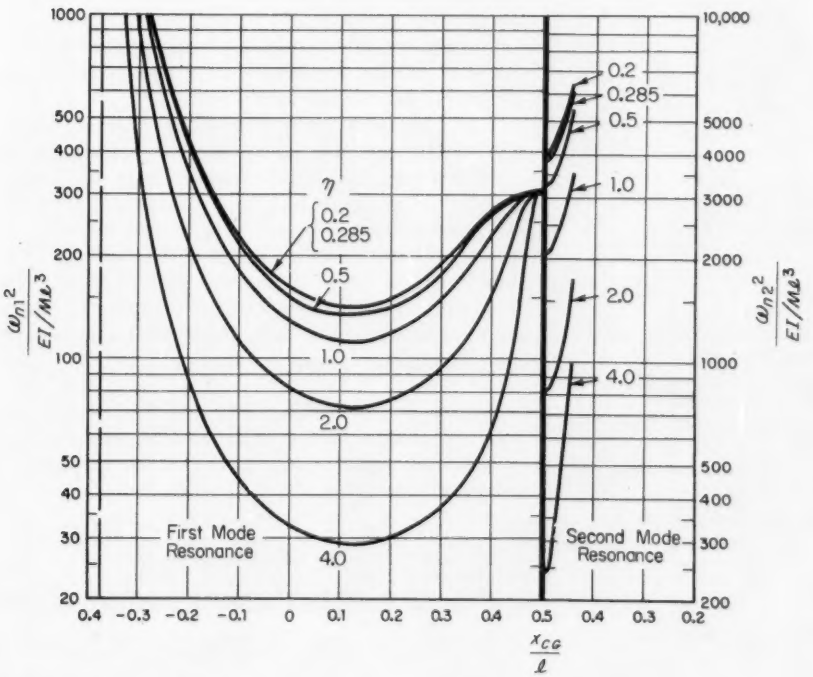


Fig. 10—$\kappa = 0.75$

For example, consider the case where $\xi = 0.3$, $\eta = 0.5$, and $\kappa = 0.40$. This situation falls between the charts of Fig. 7 and 8. To find the values of ω_{n1} and ω_{n2}, an interpolation chart will have to be constructed. Procedure is:

1. Select a series of κ values, corresponding to the charts in Fig. 5 through 10, which bracket the intermediate value.
2. Calculate the value of x_{CG}/l for each κ value from

$$\frac{x_{CG}}{l} = \frac{x}{l} + \frac{a}{2l}$$

or

$$\frac{x_{CG}}{l} = \xi + \frac{\kappa}{2}$$

3. Find the ordinates of the first and second-mode resonances (Fig. 5 through 10), corresponding to the values of κ, x_{CG}/l, and η. Keep in mind the mirror relationship for values of x_{CG}/l above and below 0.5. For example the resonances at $(x_{CG}/l) = 0.55$ are the same as those at $(x_{CG}/l) = 0.45$.
4. Construct plots of κ versus the ordinates for the first and second-mode resonances obtained in step 3.
5. Find the ordinate values corresponding to the intermediate κ value from these plots.

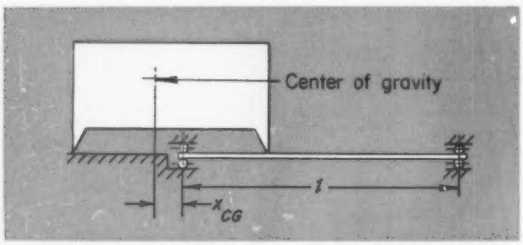


Fig. 11—Single-point suspension. For this position of the suspended item, x_{CG}/l has a negative value because the center of gravity is to the left of the left beam support.

Table 2—Interpolation Data

κ	$\frac{x_{CG}}{l}$	$\frac{\omega_{n1}^2}{EI/Ml^3}$	$\frac{\omega_{n2}^2}{EI/Ml^3}$
0.1	0.35	60	16,000
0.2	0.40	58	4,800
0.333	0.467	66	2,400
0.5	0.55	98	2,000
0.625	0.6125	155	5,000

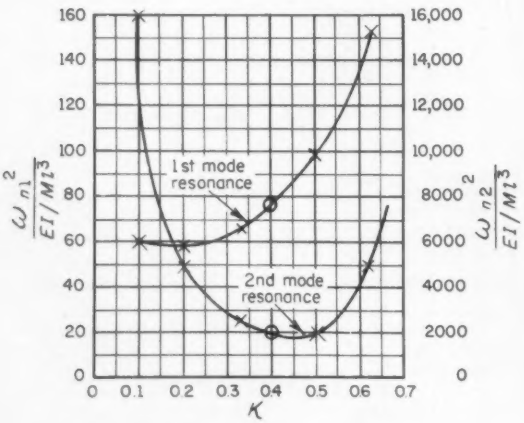


Fig. 12—Interpolation chart. Plots are based on data given in Table 2.

For the example considered here, the interpolation data are given in Table 2. The interpolation chart based on these data is shown in Fig. 12. From this chart at $\kappa = 0.40$,

$$\frac{\omega_{n1}^2}{EI/Ml^3} \approx 76$$

$$\frac{\omega_{n2}^2}{EI/Ml^3} \approx 1800$$

The graphical results can be also used in a variety of other ways. For instance, foundation stiffness (as expressed by flexural rigidity EI) can be selected to give suitable resonance values for an item attached at a certain position.

The charts in Fig. 5 through 10 are also useful for qualitative evaluation of certain design factors. For instance, if the suspended item is long and thin (small κ, large η) the second-mode resonance is appreciably influenced by altering the dimension, b. However, the lower resonance value, which is usually of greater importance, is negligibly affected by such alteration, except at low x_{CG}/l ratios, Fig. 5.

At low x_{CG}/l ratios, the ratio of angular to linear motion of the mass increases at resonance. The rotary motion is a function of the rotary moment of inertia, I_M which is directly proportional to b^2. Consequently, the first mode resonance is significantly influenced by an increase in b, but only at low x_{CG}/l ratios.

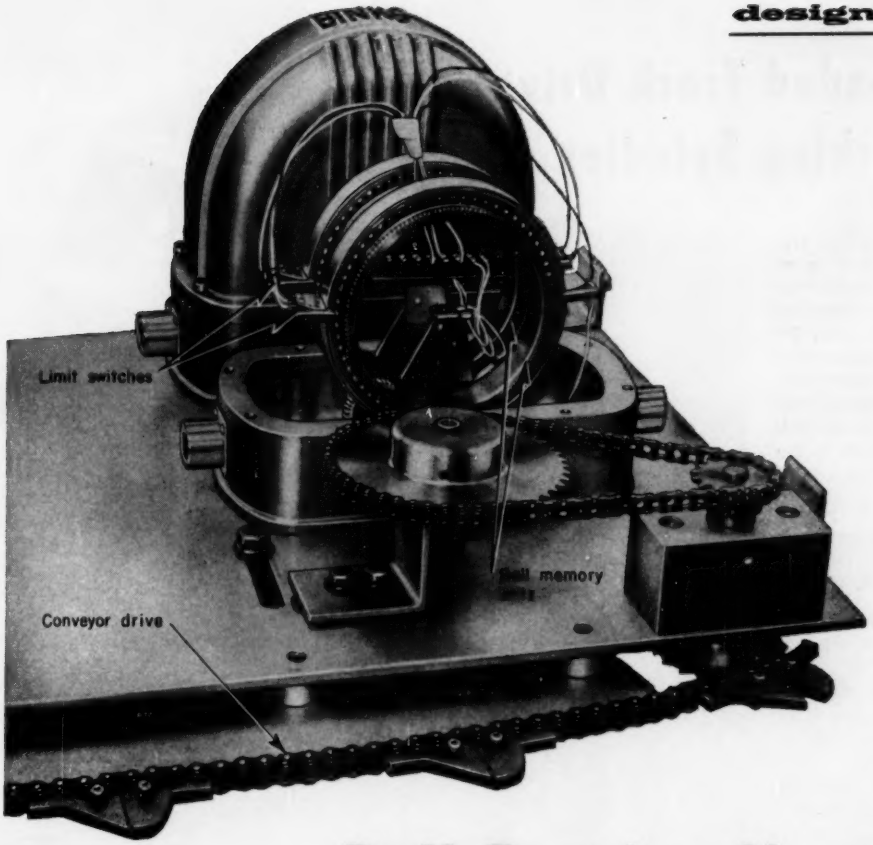
Another interesting property is associated with $\kappa = 0.2$ and $\eta = 4$, or $\kappa = 0.625$ and $\eta = 0.5$, 0.285, or 0.20. Inspection of the first-mode resonance curves for these situations indicates that these frequencies are quite independent of the position of the suspended item along the foundation. In these situations, the resonant frequency cannot be significantly increased by moving the suspended item nearer to the foundation supports. Other measures apparently must be taken if the first resonance is to be elevated above a certain frequency excitation range.

For suspended items with large bases (that is, $\kappa = 0.75$), the effect of moving the suspended item nearer to the foundation supports takes a different trend than might be expected, as evidenced from the first-mode resonance curves. Here, the influence of the rotary inertia of the suspended item and the flexibility of the beam at the one beam-supported leg position actually lowers the first-mode resonance value when the item is mounted with one support at a foundation support position.

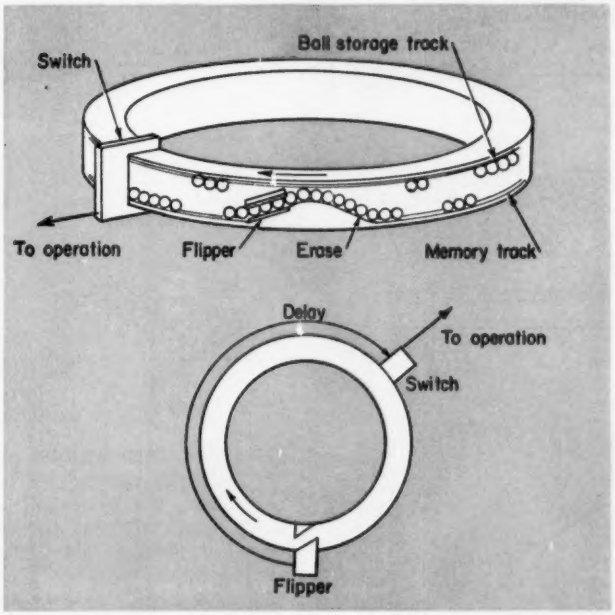
Second and concluding article of this two-part series will deal with the application of the graphical and tabular response data in the solution of practical design problems.

REFERENCES

1. J. N. Macduff and J. R. Curreri—*Vibration Control*, McGraw-Hill Book Co. Inc., New York, 1958, pp. 119, 120.
2. Reference 1, p. 29.
3. R. H. Scanlon and R. Rosenbaum—*Introduction to the Study of Aircraft Vibration and Flutter*, The Macmillan Co., New York, 1951, p. 128.
4. S. Timoshenko—*Strength of Materials, Part* 1, D. Van Nostrand Co. Inc., Princeton, N. J., Third Edition, 1955, p. 95.



Ball-Bearing Memory Programs Handling Sequence



GEARED to a conveyor, a ball memory wheel keeps track of product progress toward operation stations. Actuated by a limit switch at the conveyor entrance, a flipper deflects balls into a circular track each time a product enters the conveyor.

As the product moves down the line, the ball moves around the track. Limit switches, positioned on the ball's course, correspond to operation stations along the conveyor.

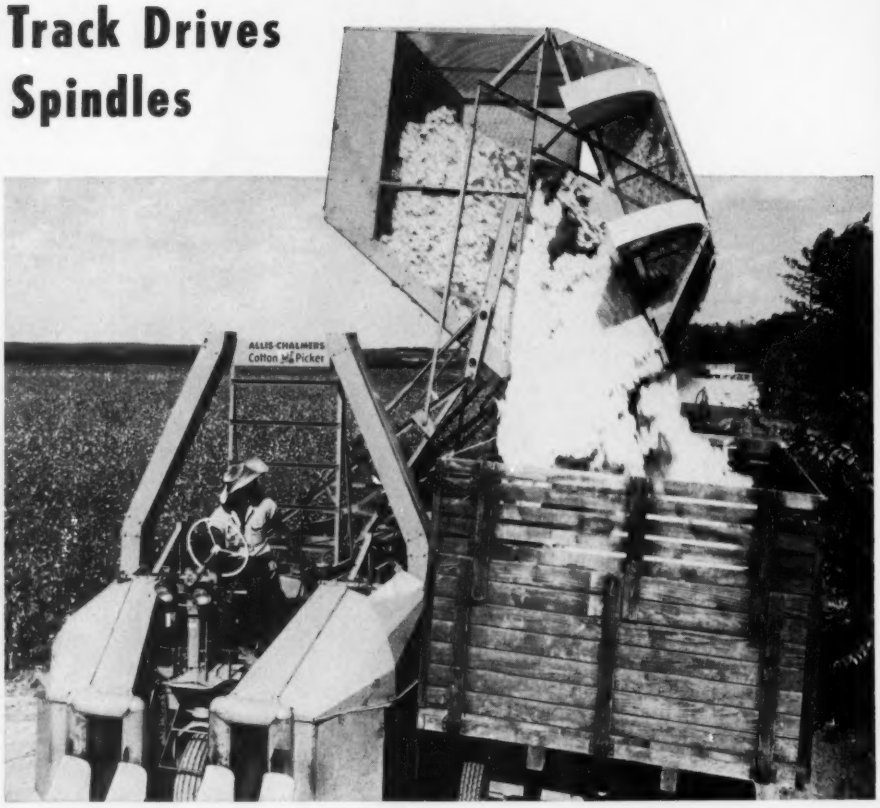
Since ball and product simultaneously reach corresponding spots, an operation (triggered when the ball trips a limit switch) occurs just as the product is in position. Electromechanical ball memory is a product of Binks Manufacturing Co., Chicago.

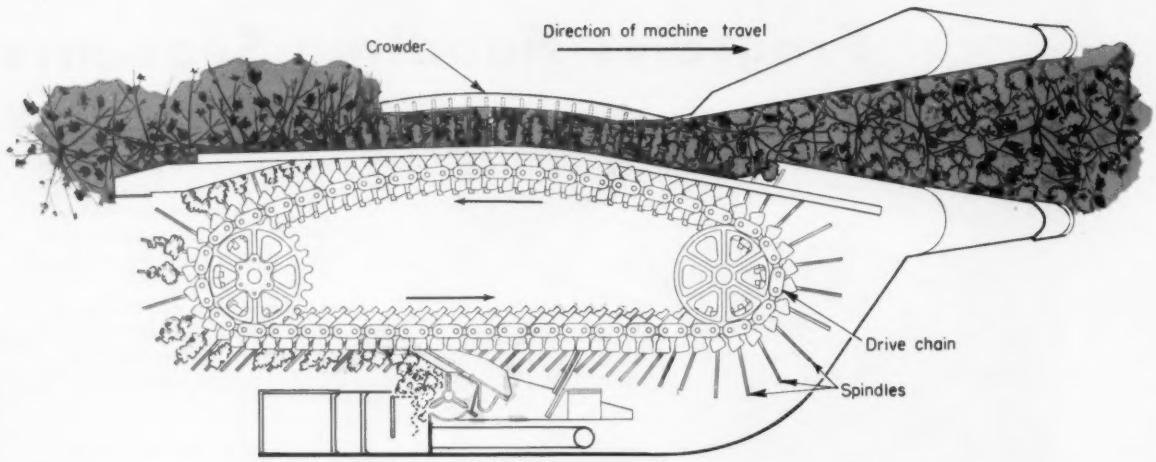
Spring-Loaded Track Drives Cotton-Picking Spindles

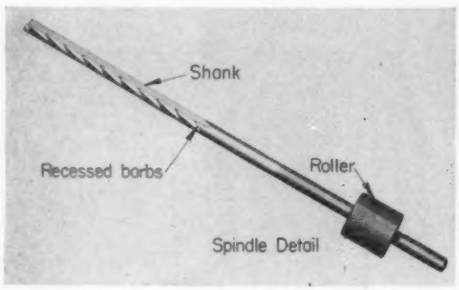
UNIQUE picking and loading system in a new cotton picker moves the cotton from the plant into the loading basket with a minimum of contact with moving parts. Fibers arrive at the processing plant with very little twist and snarl. Seeds, a valuable by-product, are less apt to be cracked or smashed. Two innovations contribute to the improved condition of the cotton:

- Intermittent drive of picking spindles twirls them only during the picking operation. While a spindle is being stripped, there is no rotary motion.

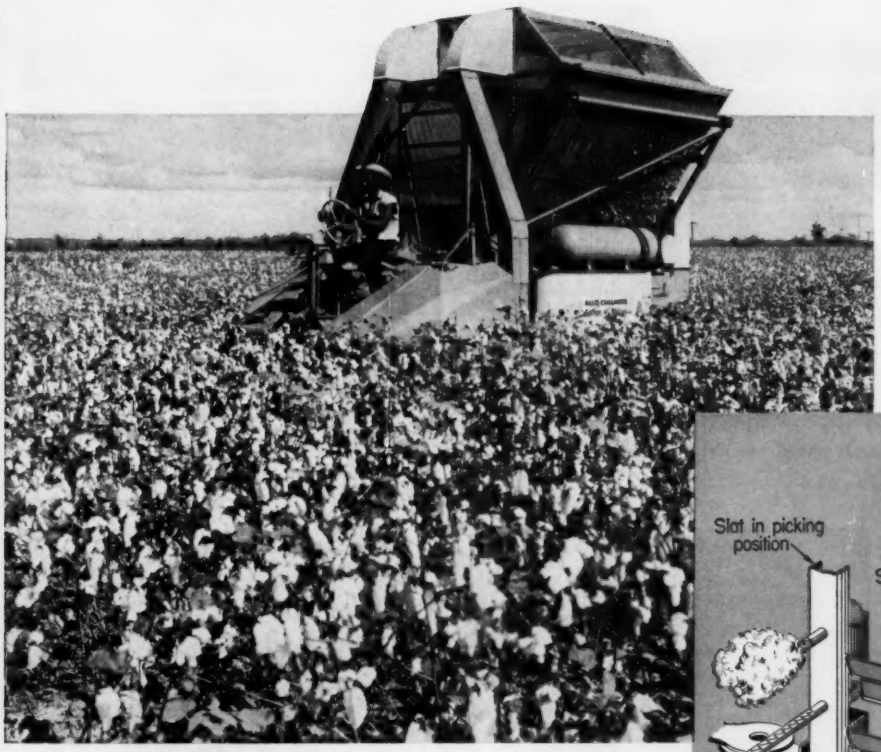
- The cotton is borne to the basket on an air stream. Previous designs used conveyors or vacuums. Each method caused the cotton to come in contact with moving parts. The model 622 two-row cotton picker is built by Allis-Chalmers at its LaPorte, Indiana, plant.



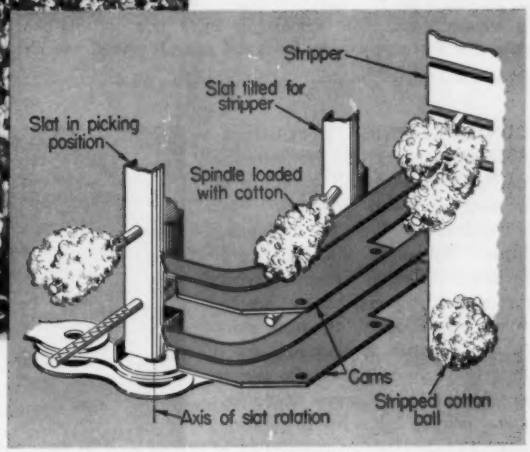




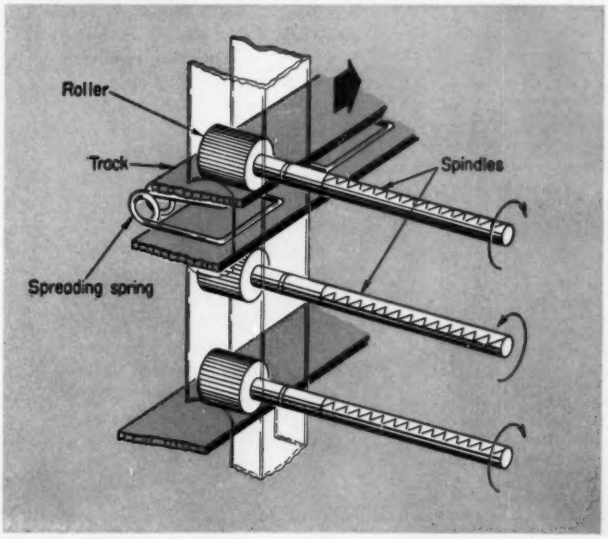
RECESSED BARBED SPINDLES pick the cotton by catching the lint and rolling the fuzzy ball on their shanks. Plants are not damaged because there is no relative motion between plants and drive chain. Forward motion of the picker exactly equals backward motion of spindles.



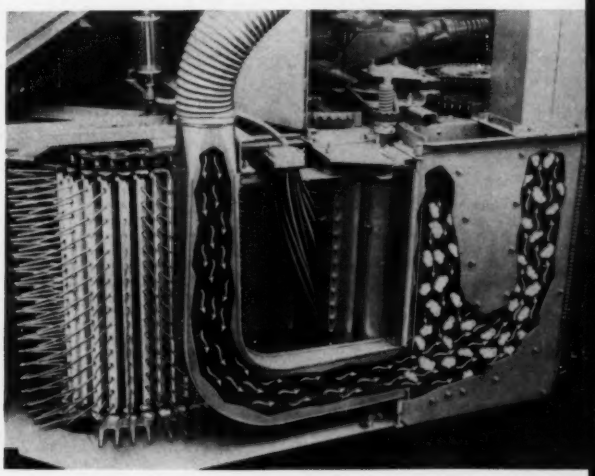
SLATS holding the spindles are tilted back by cams as they leave the picking area with their loads of cotton. This puts the spindles in the right position to pass through the stripper. Stripping fingers pull cotton from the spindles as they pass between them. A beater paddles the cotton into the air stream.

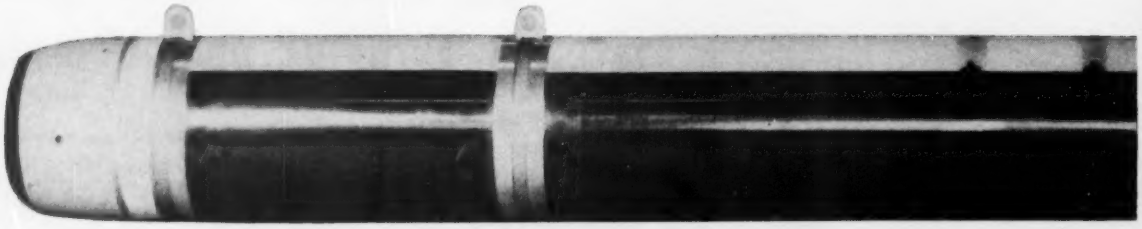


SPRING-LOADED rubber tracks twirl the spindles as they pass through the picking part of the cycle. Each set of tracks is straddled by pairs of spindles.



COTTON drops into a stream of moving air and is whisked through a riser into a loading basket. In vacuum systems, the cotton must pass through impeller blades with consequent damage to cotton seeds. In this system the impeller is behind the cotton.

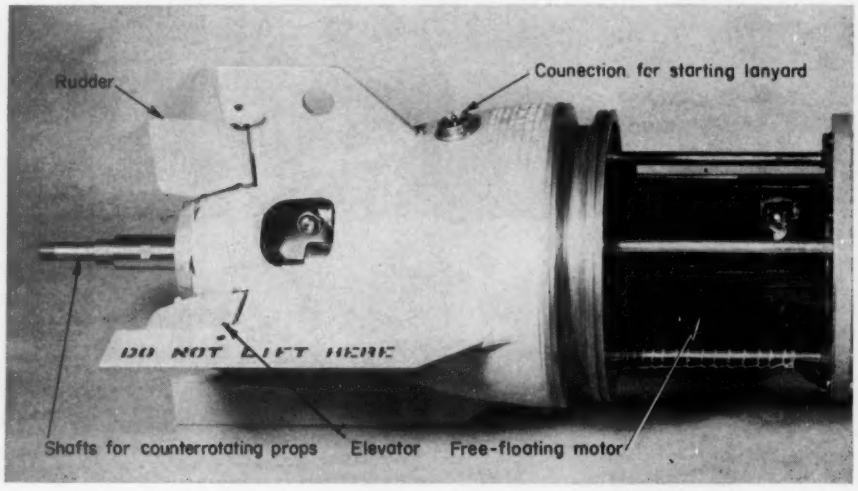


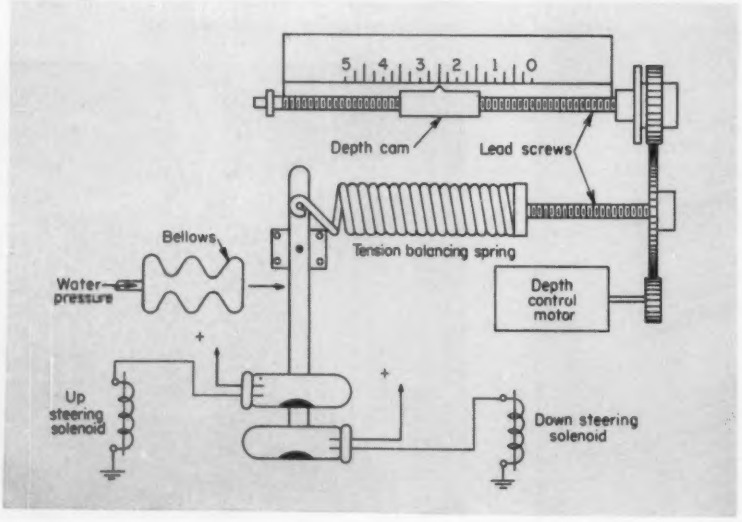


Bang-Bang Controls

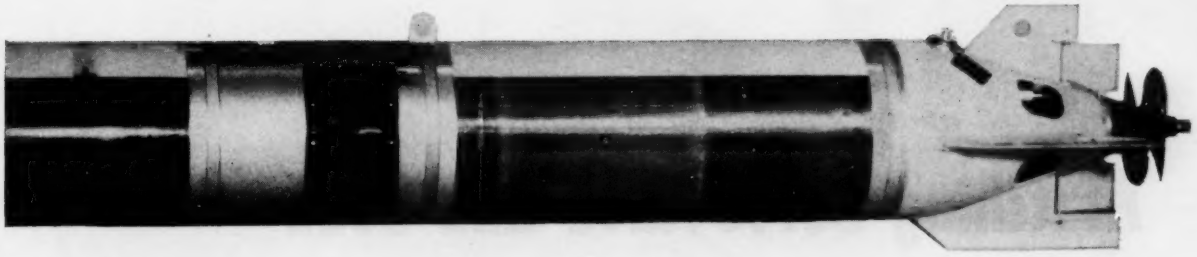
SONAR operators have learned their trade by playing fox and hounds with the Navy's U-boats. Now the submarines are released from their school role by a new torpedo-like device that acts and sounds like a real sub. It's small enough to be carried on a helicopter, and simple enough to be relatively trouble-free. A dye marker makes it easy to spot for pickup. The sub simulator was developed and built for the Navy by Clevite Corp., Cleveland, Ohio.

COUNTERROTATING propellers, driven through coaxial shafts by the free-floating field and armature of an electric motor, eliminate need for stabilizing fins to counteract torque. Sub motor starts and programmed mission begins when start switch is actuated by remote-control cable or by lanyard start. The start switch is detained by a pin. The lanyard pulls the pin to start the sub in a manner analogous to the arming of a hand grenade. Rudders and elevators are deflected by simple "bang-bang" (on-off) controls. Each is operated by two solenoids—one for each direction of motion. With solenoids off, control surfaces passively follow the streamline flow.

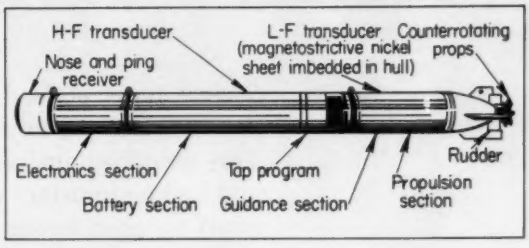




DEPTH CONTROL is a barometric diaphragm balanced by a spring. When spring and water-pressure forces reach equilibrium, the mercury switch levels off. When the underwater drone departs from programmed depth, the mercury switch tilts, applying correction to elevator solenoids. A servomotor changes spring tension for a change in program depth. Besides controlling depth, this system also controls pitching, since a tilt of the craft will actuate the mercury switch, just as a change in depth will.

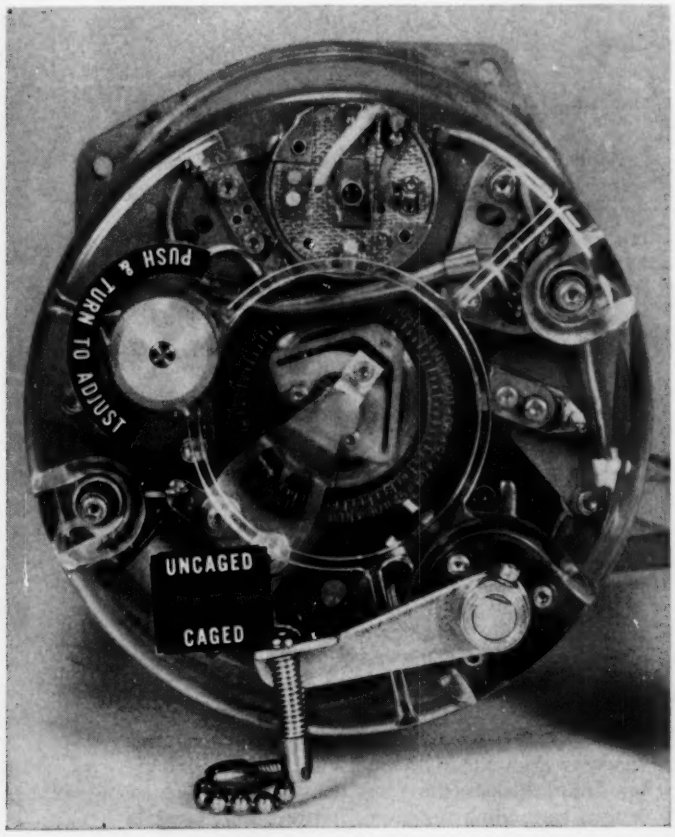


Guide Sub Simulator



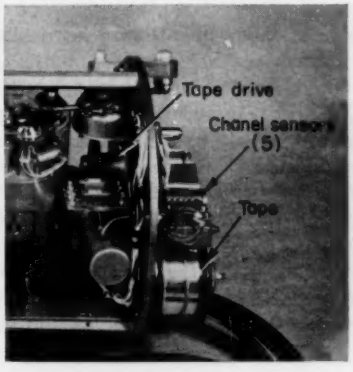
GLASS-FIBER HULL of the sub simulator is built in sections—each containing one of the operating functions. The simulator is positively buoyant and comes to the surface when its program is complete. Joints between segments are locked by a snap-ring and wedge combination that makes a streamline fastening.

Electronics equipment includes receiver in the nose for sonar "pings," amplifying equipment to give the "echo" the right volume, a transmitter to produce submarine-like noises—principally the swish of the screw—and two transducers to transmit the noises. The high-frequency "tweeter" simulates echos and high-pitched prop swish. The low-frequency "woofer" a magnetostrictive nickel sheet imbedded in the case of the guidance section, transmits engine rumble. Proper programming can produce propeller sounds for fast or slow moving craft, can simulate broken propeller blades, and otherwise individualize the craft that is being simulated.



AZIMUTH heading is controlled by a gyro compass. Desired course is set on a compass card driven by a dime-sized servomotor. When compass and card are not in line, error contacts send a signal to the proper rudder solenoid. Slow or fast turns to simulate large or small subs can be made by controlling speed of the servomotor.

TAPE CONTROL containing program for the simulator's mission has five channels: Left, Right, Up, Down, and Stop. Signals from the first two channels operate the compass-card servomotor. The third and fourth operate the spring-setting servo in the depth control. The last channel actuates cutoff of the propeller motor.



Simplified analysis eases the problems of

Matching Servovalve and Load

R. J. PROCACCINO, Project Engineer, Servocontrol Div., Oilgear Co., Waltham, Mass.

Several types of load control can be provided by the proper use of the inherent characteristics of servovalves. This simplified analysis of the relationship of servovalve and load performance provides the basic information necessary for good system design. Future articles will discuss details of using servovalves to provide control of position, velocity, and force.

APPLICATION of servovalves in electrohydraulic control systems requires an understanding of both the basic principles of servovalves and the practical analytical expressions which describe the dynamic behavior of a servovalve-load combination.

This article presents the principles of a single-stage servovalve and an analysis of a four-way servovalve controlling a load cylinder. Additionally, transfer functions for use in position, velocity, pressure, and force feedback-control systems are discussed.

Internal Construction

An electrohydraulic servovalve is an electrically controlled metering device that provides continuously adjustable fluid flow to and from an actuating device. The flow is varied by controlling the open area of multiple orifices in the valve—as contrasted to on-off control where flow is either blocked or presented with a fixed restriction.

In single-stage servovalves, minute variations of flow can be obtained by varying these orifice openings. A limitation on the smallest increment of flow is usually imposed by the mechanical device which adjusts the orifices. Generally, this device is a torque motor in which the armature deflection is proportional to an electrical signal supplied to the windings.

Basic Principles: Flow through an orifice creates a pressure drop comparable to the voltage drop produced by current flow through a resistance. Thus an internal impedance to flow is suggested. For hydraulic flow of a relatively incompressible fluid through an orifice, the nonlinear relationship is defined by Bernoulli's equation, $Q = KP^{0.5}$.

Flow coefficient K is a measure of the "conductance" of the orifice. The coefficient is determined by size and construction of the orifice and density of the fluid.

Because of this pressure-flow relationship, a servovalve may be used to control both pressure across an actuator and flow to its working areas.

Swing-Plate Details: A four-way, swing-plate servovalve, Fig. 1, consists of three components: 1. The valve body which contains three ports. 2. The valve plate which incorporates the lands required to vary the size of the control orifices. 3. Cantilever springs which support the valve plate.

The torque motor moves the valve plate in response to a direct current applied to the control windings. Movement of the plate over the stationary body changes the restrictions of orifices 1 to 4, thus controlling flow and pressure drop through

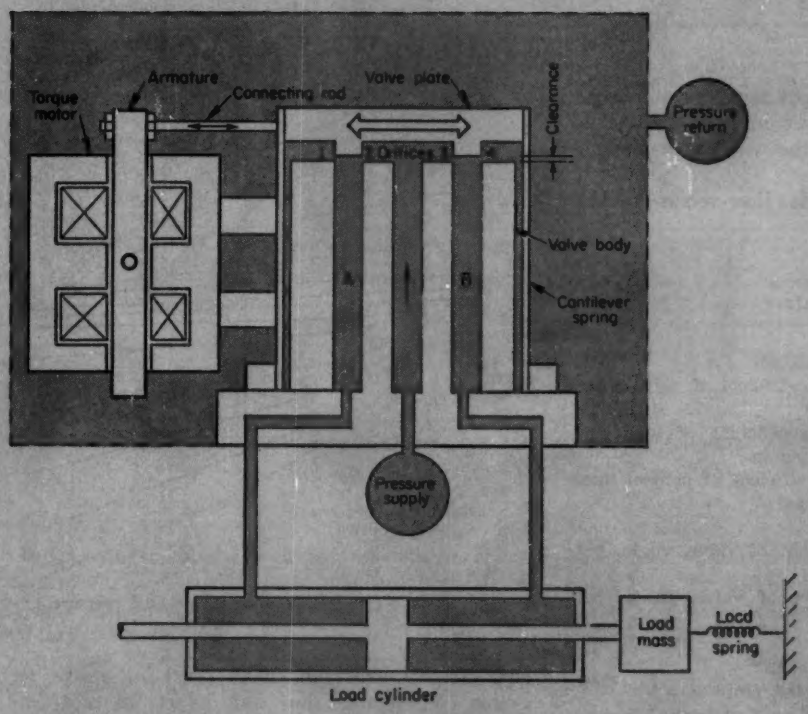


Fig. 1—Four-way, swing-plate servovalve and load cylinder.

the valve. Clearance between the valve plate and body prevents metal-to-metal contact.

Movement of the plate to the right exposes cylinder port B to the pressure inlet, and connects port A to the return. Thus, fluid flows down through port B to one side of the load cylinder and up into port A from the opposite side of the load cylinder and the piston moves to the left. Plate movement in the opposite direction causes movement of the piston to the right.

In this type of valve, the lands and ports are carefully machined to eliminate overlap or underlap of the metering edges. However, because of the clearance between the plate and body, slight orifice openings exist at the neutral position of the valve. Leakage flow occurs across these orifices from the pressure inlet to the return side of the pressure supply.

Pressure drops across all four orifices are equal due to the identical orifice areas. Thus, the pressure in ports A and B is equal to one-half the supply pressure and there is no pressure drop across the piston.

Performance Characteristics

Approximate indications of the expected performance of a servovalve can be obtained by plotting data from direct measurement of flow and pressure drop through the valve.

Flow versus Pressure: This characteristic is shown in Fig. 2. Because pressure supply is fixed, these curves also indicate the relationship between valve-output flow and valve pressure drop. For convenience, flow is usually plotted against load pressure.

Since coefficient K in the valve-orifice relationship, $Q_v = KP_v^{0.5}$, varies with orifice area, a curve is required for each valve displacement. Thus, a family of curves is required to cover the entire operating region.[1] For an underlapped valve, the relationship becomes more linear and the curves tend to straighten.

Valve flow depends on both valve displacement and load pressure, and may be defined as $Q_v = C_1x - C_2P_l$.

C_1 is the partial derivative of flow with respect to valve displacement at a constant load pressure. On the family of curves this value is the vertical distance between successive displacement curves. C_2 is the partial derivative of flow with respect to load pressure at a constant valve displacement. This value is the slope of the curves.

Both C_1 and C_2 vary considerably over the valve operating range. For stability analysis, only small valve displacements from neutral are considered. In

[1]References are tabulated at end of article.

this range, C_1 and C_2 remain fairly constant. C_1 and C_2 are important factors in determining the dynamic characteristics of the valve-actuator-load combination.

To obtain experimentally the flow-versus-pressure characteristic over the entire operating range requires considerable time and effort. In most instances, an approximate measure of servovalve performance may be obtained by measuring the no-load flow characteristic and the static-pressure-gain characteristic.

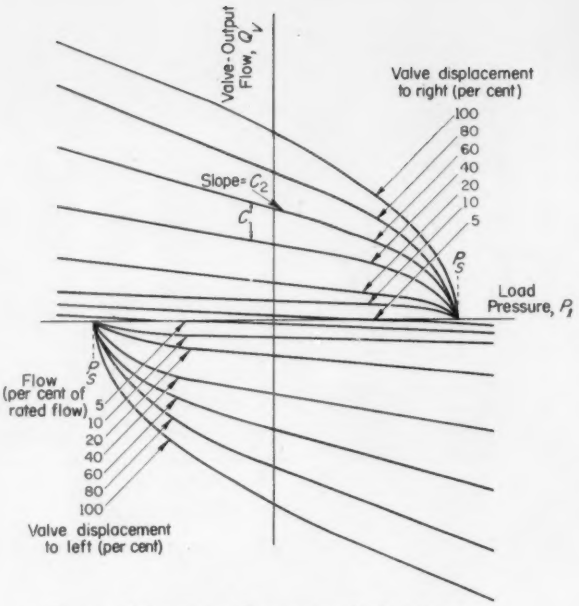


Fig. 2—Valve-output flow versus load pressure.

Nomenclature

A	=	Piston area, sq in.
B	=	Bulk modulus of oil, psi
B_1	=	Viscous-damping coefficient of valve plate, lb per in. per sec
B_2	=	Viscous-damping coefficient of load and piston, lb per in. per sec
C	=	Compressibility coefficient of control lines and oil, cu in. per psi
	=	$K_s + V/4_B$
C_1	=	Flow-gain coefficient of valve, cu in. per sec per in.
C_2	=	Pressure coefficient of valve, cu in. per sec per psi
F_r	=	Piston force, lb
F_t	=	Torque-motor force, lb
I	=	Torque-motor current, amp
K	=	Flow coefficient
K_2	=	Load spring constant, lb per in.
K_c	=	Elasticity coefficient of control line, cu in. per psi
K_f	=	Spring constant of flow-reaction force, lb per in.
K_l	=	Coefficient of leakage flow across piston, cu in. per sec per psi
K_s	=	Spring constant of torque motor and valve cantilever springs, lb per in.
M_1	=	Mass of valve plate and torque-motor armature, lb per in. per sec^2
M_2	=	Mass of load and piston, lb per in. per sec^2
P	=	Pressure, psi
P_l	=	Load differential pressure, psi
ΔP_l	=	Increment of load differential pressure, psi
P_s	=	Supply pressure, psi
P_v	=	Valve pressure, psi
Q	=	Fluid flow, cu in. per sec
Q_v	=	Total valve flow, cu in. per sec
q_c	=	Compressibility flow in control lines and load cylinder, cu in. per sec
q_l	=	Leakage flow across load piston, cu in. per sec
q_p	=	Valve flow due to load pressure, cu in. per sec
q_r	=	Flow to load piston, cu in. per sec
q_x	=	Valve flow due to valve plate displacement, cu in. per sec
S	=	Derivate with respect to time, sec^{-1}
Δt	=	Increment of time, sec
V	=	Total volume of oil under compression in control lines and cylinder, cu in.
x	=	Valve-plate position, in.
dx/dt	=	Valve-plate velocity, in. per sec
d^2x/dt^2	=	Valve-plate acceleration, in. per sec^2
y	=	Load-piston position, in.
dy/dt	=	Load-piston velocity, in. per sec
d^2y/dt^2	=	Load-piston acceleration, in. per sec^2
ω_n	=	Natural resonant frequency, radians per sec
ζ	=	Damping ratio

No-Load Flow: This characteristic, Fig. 3, is shown by a plot of valve output flow versus valve displacement, with the total supply pressure available as pressure drop across the valve. No-load flow can be plotted as a line along the $P_l = 0$ axis of Fig. 2. The curve is linear since the relationship $Q_v = KP_v^{0.5}$ becomes $Q_v = K'P_s^{0.5}$, in which P_s is a constant. The slope of the curve is equal to the value of C_1 at $P_l = 0$.

Data to plot this curve can be obtained from measurements of flow, at various valve displacements, taken with the control ports externally connected.

Static-Pressure Gain: A plot of load pressure versus displacement, Fig. 4, provides a measure of static-pressure gain. Static-pressure gain can be plotted as a line along the $Q_v = 0$ axis of Fig. 2. This characteristic provides a measure of the valve's ability to generate load force. This is an important consideration in most closed-loop systems in which accuracy depends on system ability to overcome load static friction with a small valve movement. The steeper the static-pressure-gain characteristic, the better the system's capability to generate load force for a given valve displacement.

The slope of the curve is equal to C_1/C_2 at zero-load flow. This quantity is approximately inversely proportional to the cross-port leakage flow. A valve with zero leakage would have a pressure-gain curve of infinite slope. A minute movement of the valve would develop full supply pressure across the load. As leakage increases, the slope decreases.

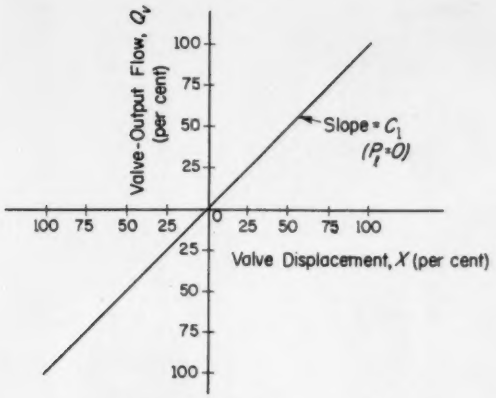


Fig. 3—No-load flow characteristic.

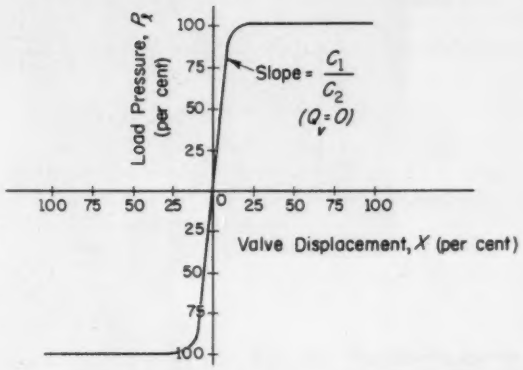


Fig. 4—Static-pressure-gain characteristic.

In a swing-plate valve design, movement of a 0.001 to 0.002-in. portion of a total stroke of 0.015 in. is a typical displacement necessary to produce full-load pressure.

The static-pressure-gain characteristic may be obtained directly from the blocked-port pressure characteristic.

Blocked-Port Pressure: This characteristic, Fig. 5, is shown by a plot of control-port pressure versus valve-plate displacement with zero flow to the load. Zero-load flow measurements may be obtained while the control ports of the valve are blocked.

Leakage flow across the valve orifices establishes a pressure in each control port equal to one-half the supply pressure, with the valve plate at the neutral position. With the control ports blocked, a change in control-port pressure is produced by movement of the valve plate from neutral. This pressure change is caused by the relative change in orifice areas. If the valve plate is moved to the right, Fig. 1, the pressure drop due to leakage flow across orifices 1 and 3 decreases, while the pressure drop across orifices 2 and 4 increases. Thus, the pressure in port B increases and that in port A decreases.

A plot of these pressures for valve-plate displacement in both directions produces the blocked-port pressure characteristic curves. The difference between these curves represents pressure across the load. A plot of the differential pressure represents the static-pressure-gain characteristic.

Dynamic Analysis

In the following analysis of a four-way, swing-plate valve driving a piston actuator, analytical expressions describe the relationships between valve displacement and piston position, velocity, and force. These expressions are in the form of transfer functions employing the La Place transform notation. For the sake of simplicity and practicality, many second-order effects such as friction, temperature, changes in oil characteristics, and hysteresis are neglected.

Results of the analysis are represented diagrammatically in Fig. 6. This functional block diagram indicates the dynamic relationships in the valve actuator-load system.

Valve Mechanical Response: In an analysis of a valve-load system, the response of the mechanism used to vary the valve orifices must first be determined. In the swing-plate servovalve, this response is the relationship between valve-plate position (output) and torque-motor force (input).

The transfer function describing this response may be developed from the force equation:

$$F_t = M_1 \frac{d^2x}{dt^2} + B_1 \frac{dx}{dt} + (K_s + K_f)\, x \qquad (1)$$

By the La Place notation:

$$F_t(s) = (M_1 S^2 + B_1 S + K_s + F_f)\, X(s) \qquad (2)$$

Thus, the response transfer function is

$$\frac{X(s)}{F_t(s)} = \frac{\frac{1}{K_1}}{\frac{M_1}{K_1} S^2 + \frac{B_1}{K_1} S + 1} \qquad (3)$$

where

$$K_1 = K_s + K_f$$

This expression is typical of a mass spring sys-

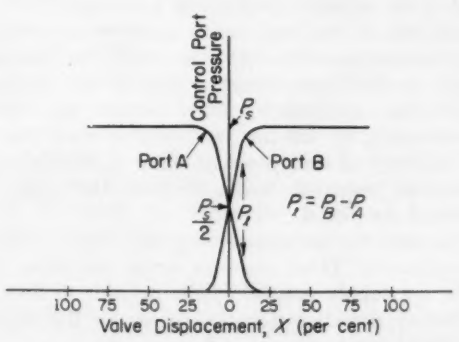


Fig. 5—Blocked-port pressure characteristic.

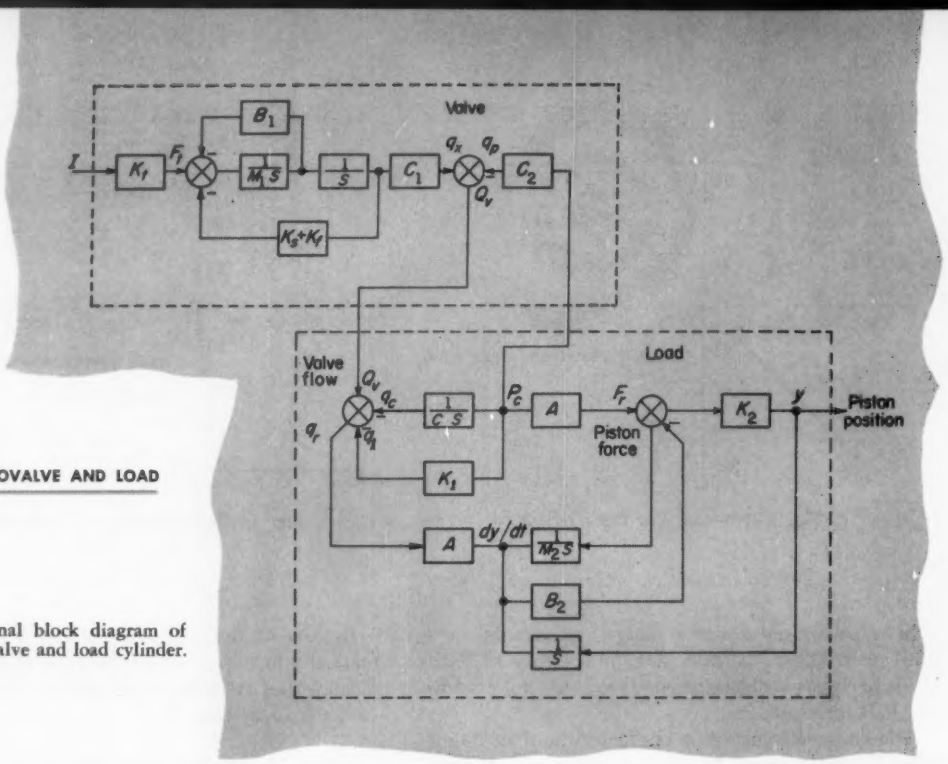


Fig. 6—Functional block diagram of four-way servovalve and load cylinder.

MATCHING SERVOVALVE AND LOAD

tem with an undamped mechanical resonant frequency of

$$\omega_n = \sqrt{\frac{K_s + K_f}{M_1}} \qquad (4)$$

K_f is a spring force created by the flow of oil through the valve. This coefficient varies as the square root of the supply pressure.

For the swing-plate valve ω_n normally ranges from 200 to 300 cps. In most applications, this value is considerably higher than the critical frequencies of the overall system. Therefore, the valve mechanical response may be considered equal to a constant.

Load Response to Flow: After the mechanical response of the valve is determined, load response to flow from the valve is investigated.

Flow from the valve results from a difference between theoretical flows q_p and q_x, where $q_p = C_2P_1$ and $q_x = C_1x$. Flow q_p is the result of dependence of flow on pressure drop. Flow q_x is the flow that would exist if the total supply pressure were available across the valve. However, since the pressure supply is fixed, any pressure drop across the load lowers the available pressure across the valve. Therefore, q_p is the loss in available flow due to the existence of load pressure. Flow q_p may also be considered negative feedback from the load, as indicated in Fig. 6.

However, for an overhauling load, P_l is a negative quantity. Thus, pressure across the valve exceeds the supply pressure. Flow q_p adds to flow q_x producing the characteristics shown in the second and fourth quadrants of Fig. 2.

Flow from the valve is composed of three parts: 1. Flow q_r which imparts a velocity to the piston. 2. Leakage flow q_l across the piston. 3. Compressibility flow q_c.

Piston flow q_r, considered as useful flow, is defined as

$$q_r = A\frac{dy}{dt} \qquad (5)$$

Leakage flow q_l, which represents a flow loss, is proportional to differential load pressure if the flow is considered to be laminar. Thus,

$$q_l = K_l P_l \qquad (6)$$

Compressibility flow q_c also represents a flow loss. This flow is required to compensate for the oil-volume change that occurs in the control lines and load cylinder when a differential load pressure is applied. The change in volume is due to the elasticity of both the lines and the oil. Since the change in oil volume is directly proportional to load differential pressure, the change of volume per unit time (flow) is proportional to the rate of change of load pressure. Thus,

$$q_c = C\frac{\Delta P_l}{\Delta t} \qquad (7)$$

This expression for compressibility is valid for small displacements of the piston from its mid-stroke position. At mid-position, compressibility effects are most severe in a four-way control system.[2]

Total valve flow is $Q_v = q_r + q_l + q_c = q_x - q_p$.

Load Pressure: The pressure developed across the piston creates, on the pistonface, a force which can be used to do work on the load. This force is used

to accelerate the load mass, overcome viscous friction, and deflect the load spring. Static friction and other load disturbances are considered to be zero. Piston force is defined as

$$F_r = P_l A$$
$$= M_2 \frac{d^2y}{dt^2} + B_2 \frac{dy}{dy} + K_2 y$$

Thus,

$$P_l = \frac{1}{A}\left(M_2 \frac{d^2y}{dt} + B_2 \frac{dy}{dt} + K_2 y\right) \quad (8)$$

Control Capabilities

Servovalves can be included in a system to provide any of several types of control. Primarily, this capability results from the pressure-flow relationship which permits a servovalve to control both pressure across an actuator as well as flow to the working area.

Equations 5 through 8 can be combined and rearranged to provide a useful design expression for the relationship between piston position and valve-plate position:

$$\frac{Y(s)}{X(s)} = \frac{a_1}{a_2 S^3 + a_3 S^2 + a_4 S + a_5}$$

where $a_1 = C_1 A$; $a_2 = CM_2$; $a_3 = (K_l + C_2)M_2 + CB_2$; $a_4 = (K_l + C_2)B_2 + CK_2 + A_2$; and $a_5 = K_2(K_l + C_2)$.

Position: If load spring, piston leakage, and viscous friction are considered negligible, the transfer function of piston position versus valve-plate position is

$$\frac{Y(s)}{X(s)} = \frac{\frac{C_1}{A}}{S\left(\frac{CM_2}{A^2} S^2 + \frac{C_2 M_2}{A^2} S + 1\right)} \quad (9)$$

The undamped natural frequency of the system is

$$\omega_n = \sqrt{\frac{\frac{A^2}{C}}{M_2}} \quad (10)$$

where A^2/C = the effective spring constant of oil and lines.

The damping ratio is

$$\zeta = \frac{C_2 \sqrt{M_2}}{2A\sqrt{C}} \quad (11)$$

Velocity: The ratio of piston velocity to valve-plate position is used if

$$\frac{\left(\frac{dy}{dt}\right)(s)}{X(s)} = \frac{\frac{C_1}{A}}{\frac{CM_2}{A^2} S^2 + \frac{C_2 M_2}{A^2} S + 1} \quad (12)$$

The steady-state velocity ($S \rightarrow 0$) is equal to C_1/A, which is the valve flow per unit displacement of the valve plate divided by the load-piston area.

Force Feedback: Piston output force is related to piston position by

$$F_r(s) = [Y(s)][M_2 S^2 + B_2 S + K_2] \quad (13)$$

In a force-feedback type control system, load spring is usually appreciable. If piston leakage and load viscous friction are considered negligible, the force transfer function is

$$\frac{F_r(s)}{X(s)} = \left[A \frac{C_1}{C_2}\left(\frac{M_2}{K_2} S^2 + 1\right)\right] \Big/ \left[\frac{CM_2}{K_2 C_2} S^3 + \frac{M_2}{K_2} S^2 + \frac{CK_2 + A^2}{K_2 C_2} S + 1\right] \quad (14)$$

Pressure Feedback: The relationship between load differential pressure and valve-plate position can be obtained by dividing Equation 14 by the load piston area:

$$\frac{P_l(s)}{X(s)} = \left[\frac{C_1}{C_2}\left(\frac{M_2}{K_2} S_2 + 1\right)\right] \Big/ \left[\frac{CM_2}{K_2 C_2} S^3 + \frac{M_2}{K_2} S^2 + \frac{CK_2 + A^2}{K_2 C_2} S + 1\right] \quad (15)$$

The steady state gain (at S = 0) is $P_l/X = C_1/C_2$. This value is also the static-pressure-gain characteristic of the valve.

Application

The expressions for piston position, velocity, or force versus valve displacement are in a form suitable for use in over-all system synthesis or analysis by standard servo techniques.

Although the analysis shown is for a swing-plate, single-stage servovalve, the transfer functions relating valve displacement to piston output also apply to other four-way valves such as the spool and sliding-plate type.

Additionally, these expressions can be applied to two-stage valves having a spool-type second stage. In this situation, the second-stage spool is considered equivalent to the piston load in the analysis. Feedback from the second-stage spool to the input of the first stage must then be included. The transfer function relating second-stage spool displacement and actual piston load are the same as those shown.

These expressions also apply to rotary-type actuators. For these situations, the coefficients must be converted to the corresponding rotary values.

References

1. J. F. Blackburn, G. Reethof, and J. L. Shearer—*Fluid Power Control*, John Wiley and Sons Inc., 1960.
2. R. Hadekel—"Hydraulic and Pneumatic Servos," AUTOMATION, Part 1, Oct., 1954; Part 2, Nov., 1954; Part 3, Dec., 1954; Part 4, Jan., 1955; Part 5, Feb., 1955; Part 6, March, 1955.

A design guide:

Preventing Fatigue Failures

Part 6 — Biaxial Fatigue Stresses

Fatigue calculations may be complicated by the presence of multiaxial alternating stresses. The problem can be simplified by relating these stresses to a single allowable fatigue stress.

F. B. STULEN
Assistant Chief Engineer

H. N. CUMMINGS
Consulting Engineer

W. C. SCHULTE
Chief Metallurgist

Propeller Div.
Curtiss-Wright Corp.
Caldwell, N. J.

DESIGNING structural components to withstand static combined stresses presents no special difficulties. An assortment of failure criteria is available: Maximum stresses, maximum shear, etc. However, when it is necessary to cope with the effects of combined fatigue stresses—that is, stresses in two or more directions—the problem is more complex, for a method must be found for relating these stresses to a fatigue criterion, or a single allowable fatigue stress.

A simple failure criterion[1-3] has been established for biaxial and triaxial fatigue stresses. It has been checked for both brittle and ductile materials and found to give consistently better correlation than any other method.

This criterion is expressed in terms of the principal stresses. Since biaxial stresses are a special case of triaxial stresses in which one of the three principal stresses is zero, a single criterion is expressed in terms of the largest, p_{1v}, and the smallest, p_{3v}, principal

[1]References are tabulated at end of article.

stress. In a biaxial system, if the two principal stresses are of opposite sign, the intermediate stress, $\pm p_{2v} = 0$, as shown in Fig. 26*a*; if they are of the same sign, the lowest stress, $p_{3v} = 0$, Fig. 26*b*.

Application of this criterion requires, first, the conversion of imposed alternating stresses into principal alternating stresses. Then the principal stresses are converted into an equivalent effective uniaxial alternating stress by computing the effective uniaxial principal alternating stresses:

$$S_{eff} = p_{1v} - \lambda_\theta\, p_{3v} \qquad (1)$$

This value should be kept smaller than the fatigue strength of the material. Then, for vibratory stresses, the value of S_{eff} must not exceed the allowable working stress based on $S_{e\theta}$. To solve any situation, then, it is only necessary to compare the computed value of S_{eff} to the allowable stress.

Principal Stresses

In any case of multidirectional stressing, it is possible to calculate three principal stresses, on mutually perpendicular planes. On these principal planes, the shearing stresses are all zero. Calculating these triaxial principal stresses, and their direction, involves some rather tedious computations. Fortunately, in most cases of fatigue stressing, failures nucleate on, or close to, the surface. Thus, there can be little, if any, stress in a direction normal to the surface. This means that in such cases one of the principal stresses may be assumed to be zero, and the applied fatigue stresses can be analyzed as a biaxial stress system. Parts subjected to high surface contact stresses, such as bearings, would be one exception to this general statement.

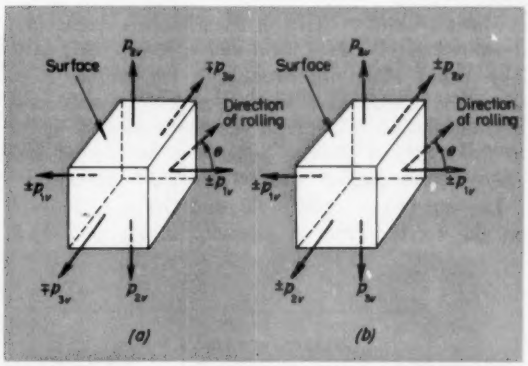


Fig. 26—General case of multiaxial principal stresses, where, *a*, principal fatigue stresses p_{1v} and p_{3v} are of opposite signs and, *b*, principal fatigue stresses p_{1v} and p_{3v} are of same sign.

The principal stresses derived from the applied biaxial stresses will, of course, be in the plane of the applied stresses, and the stress normal to their plane will be zero. If the three general principal stresses are arranged in order of magnitude, p_{1v} will be algebraically largest, p_{2v} the next, and p_{3v} the smallest.

In a biaxial stress system, one of the three principal stresses is zero. Since the applied loads cause reversed fatigue stressing, there is an instant in each cycle when at least one of the other principal stresses is at a maximum positive value. If, at that instant, the other biaxial principal stress is negative (compression) then the zero stress is between the two, and $p_{2v} = 0$. If both biaxial principal stresses are positive at the same instant, $p_{3v} = 0$. For example, in Fig. 26*a* stress values might be: $p_{1v} = +10{,}000$ psi, $p_{2v} = 0$, $p_{3v} = -5000$ psi; in Fig. 26*b*, $p_{1v} = +20{,}000$ psi, $p_{2v} = +6000$ psi, $p_{3v} = 0$.

In calculating the effective uniaxial alternating principal stress, the designer must take into account the signs of the principal stresses. This means, of course, that if the stresses are of opposite sign, the second term of S_{eff} becomes additive; if they are of the same sign, the second term becomes zero. In either case, fatigue ductility, material constant λ, and the anisotropy of the material should be considered.

Equation 1 for the effective stress was developed for the case where p_{1v} and p_{3v} reach their extreme values at the same time in each cycle. As indicated in the Nomenclature, p_{1v} and p_{3v} are the amplitudes

Nomenclature

p	= Principal stress, psi
p_{1m}	= Arithmetically largest principal steady stress, psi
p_{1v}	= Algebraically largest principal alternating stress in a cycle, psi
p_{2v}	= Intermediate principal alternating stress, psi
p_{3v}	= Smallest principal alternating stress, psi
S_e	= Fatigue strength in direct stress, psi
S_{eff}	= Effective uniaxial principal alternating stress, psi
$S_{e\theta}$	= Fatigue strength for given direction of p_{1v}, psi
s	= Direct stress, psi
s_{min}	= Minimum direct stress, psi
s_{max}	= Maximum direct stress, psi
s_x	= Stress acting normal to x-plane, psi
s_y	= Stress acting normal to y-plane, psi
θ	= Angle between direction of rolling or forging and that of p_{1v}, deg
λ_θ	= Material constant $= (S_{e\theta}/\tau_e) - 1$
τ	= Shear stress, psi
τ_e	= Fatigue strength in shear, psi
τ_{max}	= Maximum shear stress, psi
τ_{xy}	= Shear in x-plane, in y-direction, psi
τ_{yx}	= Shear in y-plane, in x-direction, psi
ϕ	= Angle between planes, deg

of fully reversed principal stresses. If a stress system is not fully reversed, it must be broken down into a fully reversed component and a mean (steady) component. Only the reversed component is used in calculating S_{eff}.

Fatigue Ductility

For an isotropic material, constant λ is one less than the ratio of tensile fatigue limit to torsional fatigue limit. For anisotropic material, λ has directional properties, as indicated by the subscript θ.

Although it has been known for a long time that the mechanism of fatigue is primarily a matter of slip, or shear, comparatively little testing has been done on the shear fatigue strength of metals. Consequently, it is necessary in most cases to use approximate values of λ based on the fatigue ductility of the material. In tests, Fig. 27, λ has correlated fairly well with static reduction of area for a number of materials for which data were available.[4] However, this is a very crude guide to fatigue performance, since static-test behavior is not strongly affected by inhomogeneities. On the other hand, fatigue behavior depends on some minute inhomogeneity and is strongly localized at the inhomogeneity. For this reason, fatigue ductility can be, and frequently is, considerably different from static ductility. However, if no data are available on the value of τ_e, so that λ cannot be computed, its value must be assumed. Table I lists some values of λ for several degrees of ductility.[4]

Although the theoretical value of λ is limited to a range of 0 to 1.0, the actual value has been occasionally found to be greater than unity. In these cases, it is likely that something—for example, stringer-like inclusions, longitudinal cracks, etc.—is causing an abnormal weakness in resistance to shear, so that τ_e is lower than usual. Such might be the case if the transverse fatigue strength were known to be very low in comparison with the longitudinal fatigue strength.

Effect of Anisotropy

Structural materials, especially if they have been forged or rolled, may have "longitudinal" fatigue strengths different from "tranverse" fatigue strengths. This property of not having the same characteristics in all directions, called anisotropy, was discussed in Part 4 of this series. In the case of multiaxial stressing of some materials, it may seriously affect the fatigue strength, since the principal stresses are rarely in the longitudinal direction.

Since λ depends on S_e, and S_e in the effective-stress formula has a subscript θ, it is obvious that λ itself has directional properties and should also have the subscript θ. Unfortunately there is very little quantitative information about how fatigue strength varies as the direction of stressing swings away from longitudinal to transverse.

Until extensive laboratory studies can be made and the laws of variation determined, the allowable strength in oblique directions should be decreased by 20 or 30 per cent. In line with this, the value of $S_{e\theta}$ used for computing λ and S_{eff} should be reduced somewhat from the longitudinal fatigue strength. The amount of the reduction is a matter of judgment except in the very rare case where definite data are available.

Sample Calculations

Case 1: A smooth structural part intended for long-life use under constant-amplitude fatigue loading has been tentatively designed. Unit fatigue stresses will be $\pm$20,000 psi in the longitudinal direction and $\pm$10,000 psi in the transverse direction. There is a shear of $\pm$13,500 psi in the transverse plane. Steel is electric-furnace aircraft quality SAE 4340, hardened to no more than Rc 40.

Is the design acceptable, or should the part be redesigned so that stresses are reduced or increased?

The design will be acceptable if S_{eff} does not exceed the allowable fatigue stress based on a long-life strength of the SAE 4340 steel under specified conditions, which include freedom from corrosion, fretting, and surface imperfections.

The first step is to compute principal stresses p_{1v} and p_{3v}, and angle θ. These can be computed by means of Mohr's circle for plane stress, Fig. 28. Not only the principal stresses, but the normal and shear stresses on any plane can be computed from Mohr's circle.

MOHR'S CIRCLE: To construct Mohr's circle, first draw rectangular axes for s and τ, intersecting at 0. The usual (but not necessary) convention is to draw the τ axis as a vertical and the s axis as a horizontal line, with positive values plotted up or to the right, as shown. Stresses to be plotted are:

$s_x = +20{,}000$ psi; $s_y = -10{,}000$ psi; $\tau_{xy} = -13{,}500$ psi

Lay out $OA = s_x = +20$, and $OB = s_y = -10$ on the s-axis. From A plot $AC = \tau_{xy} = -13.5$,

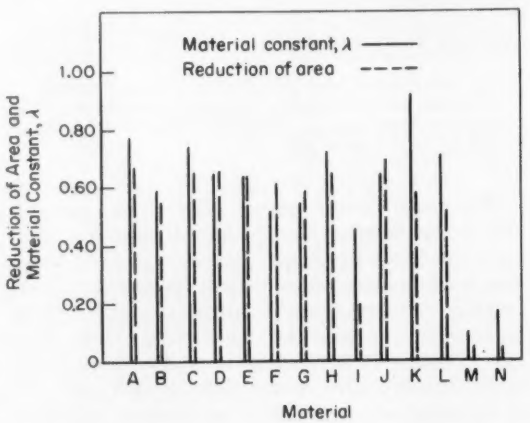


Fig. 27—Values of material constant λ and reduction of area at static fracture for various materials under test. Materials A to L are wrought; M and N are cast. This chart shows the correlation between λ and area reduction.

parallel to the τ axis, and from B plot $\tau_{yx} = +13.5$, since any shear is accompanied by an equal shear of opposite sign on a plane at right angles to it. Draw DC, crossing the s axis at E. Point E is the center, and DC is a diameter of Mohr's circle for the given data. Draw the circle, intersecting the s axis at F and G. Perpendicular EH completes the diagram.

Each point on the circumference of the circle represents, by its s and τ co-ordinates, the normal and the shear stress condition on some plane whose direction is indicated by one-half the angular distance of the point from fixed point C. Point C has co-ordinates s_x and τ_{xy}, and therefore represents conditions on the x plane of applied stress. Similarly, point D by its s and τ co-ordinates represents conditions on the y plane of applied stress. Angle 2ϕ between C and D is 180 deg, which is twice the known angle of 90 deg between the x plane and the y plane.

PRINCIPAL STRESSES: Principal direct stresses are represented by OF and OG in Fig. 28, since F and G have the maximum and minimum s co-ordinates, and zero shear. These stresses may be computed by simple geometry from Mohr's circle. Thus, $p_{1v} = OF = OE + EF = 25{,}200$ psi $= s_{max}$; $p_{3v} = OG = -(EG - OE) = -15{,}200$ psi $= s_{min}$.

The angle between the x plane and the plane of $p_{1v} = \frac{1}{2}(\tan^{-1} AC/EA) = \frac{1}{2}(\tan^{-1} 13.5/15) = 21$ deg counterclockwise.

Principal shear is represented by EH, so that $\tau_{max} = EH = +20{,}200$ psi, at 0.5 (90 deg) counterclockwise from p_{1v}; that is, at 66 deg counterclockwise from the x plane.

ALLOWABLE STRESS: Assume that a limiting (allowable) stress for an acceptable design is the long-life value of adjusted fatigue strength for Rc 41, in Fig. 21. This is 43,000 psi, reduced somewhat by an allowance for anisotropy. Computations have given only a 21-deg difference in direction between the maximum principal stress and the direction of rolling (longitudinal). This seems to warrant using only, say, 5 per cent allowance for anisotropy. Thus, the criterion, $S_{eff} = 0.95\ (43{,}000) = 41{,}000$ psi, allowable effective principal stress.

Table 1—Theoretical Values of Material Constant λ

Degree of Ductility	λ
Infinite	1.0
Medium (Forged Steel, Aluminum, etc.)	0.7
Low	0.4
Very Low (Cast Iron)	0.3
Practically None (Very Brittle)	0.2

CONCLUSIONS: If medium ductility is assumed, then from Table 1, $\lambda = 0.7$. Therefore the "effective" principal stress caused by the loads, $S_{eff} = p_{1v} - p_{3v} = 25{,}200 - 0.7\ (-15{,}200) = 36{,}000$ psi. This is somewhat less than the allowable stress, 41,000 psi, but not enough below this stress to warrant redesign.

If the steel is considered to be somewhat brittle, which might perhaps be indicated by extremely low reduction of area, it might be better to use a λ value of, say, 0.5 which would give an effective principal stress, $S_{eff} = 25{,}200 - 0.5\ (-15{,}000) = 33{,}000$ psi, which is considerably less than the allowable value.

Case 2: Assume that in Case 1, the $\pm 20{,}000$-psi stress is transverse to the direction of rolling and $\mp 10{,}000$ psi is longitudinal. The principal stresses are computed just as in Case 1, but the direction of principal stress p_{1v} is at an angle of 21 deg with the transverse direction; that is, 79 deg with the direction of rolling. This requires more reduction than previously in the allowable effective stress.

The allowance for this anisotropy is in most cases a matter of judgment. One source[4] suggests that transverse fatigue strength be taken as roughly 80 per cent of the longitudinal strength. In the present

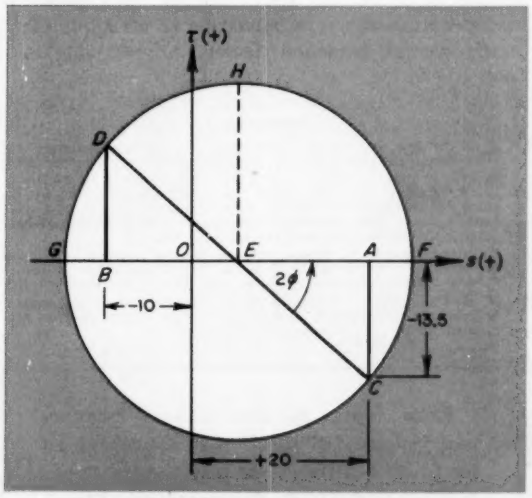


Fig. 28—Typical Mohr's circle for plane stress, Case 1. At point C, $\phi = 0$.

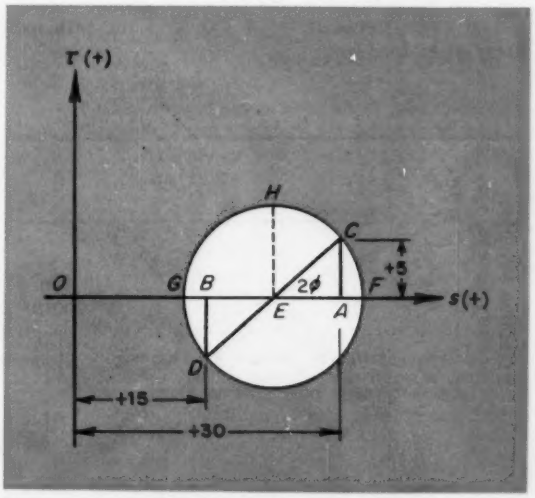


Fig. 29—Mohr's circle for Case 3. As in Fig. 28, at C, $\phi = 0$.

case, assuming a 15 per cent reduction at 79 deg, the allowable effective principal stress S_{eff} = (0.85) (43,000) = 36,500 psi. Since the computed stress is 36,000 psi, the computed stresses are acceptable.

Case 3: Assume the same steel as in Case 1 and 2, but applied stresses of ±30,000 psi longitudinal, ±15,000 psi transverse, and ±5000 psi shear.

PRINCIPAL STRESSES: For s_x = +30,000 psi; s_y = +15,000 psi, τ_{xy} = +5000 psi, Mohr's circle is shown in Fig. 29. From the geometry of the circle, $p_{1v} = OF$ = +31,500 psi; $p_{2v} = OG$ = +13,500 psi; p_{3v} = 0 (Fig. 26*b*); ϕ = −17 deg; $\tau_{max} = EH$ = +9000 psi at +28 deg with the longitudinal.

CONCLUSIONS: The criterion (S_{eff}) should be readjusted for a small amount of anisotropy, since p_{1v} is at 17 deg with the longitudinal. On the basis of a 3 per cent reduction (a purely arbitrary assumption), allowable S_{eff} = 0.97(43,000) = 42,000 psi. Assuming medium ductility, actual S_{eff} = 31,500 − 0.7 (0) = 31,500 psi. For this type of stressing, with the principal stresses having the same sign, the value of λ turns out to be immaterial.

Stresses caused by the loads are acceptable, based on the assumptions made. However, a redesign to produce somewhat higher stresses would be worth investigating.

Case 4: Identical to Case 3 but with principal stresses computed from textbook formulas.

The principal-stress formula is

$$p = \frac{s_x + s_y}{2} \pm \left[\left(\frac{s_x - s_y}{2} \right)^2 + \tau_{xy}^2 \right]^{1/2}$$

from which

$$p = \frac{30 + 15}{2} \pm \left[\left(\frac{30 - 15}{2} \right]^2 + (5)^2 \right]^{1/2} = +31{,}500 \text{ or } 13{,}500 \text{ psi}$$

The angle between the x axis and the principal stress is obtained from

$$\tan 2\phi = \frac{-2\tau}{s_x - s_y} = \frac{-10}{15}; \quad \phi = -17 \text{ deg or } +73 \text{ deg}$$

Since anisotropy is important, it is necessary to know whether p_{1v}, ±31,500 psi, is at 17 deg or 73 deg to the longitudinal. This is done by solving another formula for principal stress, to see which value of ϕ gives p = +31,500.

$$p = \frac{s_x + s_y}{2} + \frac{s_x - s_y}{2} \cos 2\phi - \tau \sin 2\phi$$

Assume ϕ = −17 deg. Then,

$$p = 22.5 + 7.5(0.83) - 5(-0.56) = 31{,}500 \text{ psi}$$

Therefore, p_{1v} is at 17 deg to the longitudinal.

As shown in Case 3, the principal stress is acceptable if it does not exceed 42,000 psi.

Special Effects

Steady Stress: In general, the principal stresses resulting from steady stresses superimposed on vibratory stresses will not act in the same direction as the principal vibratory stresses. This makes ($p_{1v} + p_{1m}$), the crest principal stress, meaningless. It has been found best to consider ($p_{1v} - p_{3v}$) as a sort of equivalent effective principal vibratory stress and to investigate the reduction of this effective stress caused by the steady p_{1m}. This amounts to using a Goodman diagram with the effective uniaxial vibratory stress as the dependent variable, and the steady major principal stress as the independent variable, Fig. 30.

Notches: It has been found experimentally that the criterion S_{eff} is valid for any type of notch subjected to combined biaxial stresses, although the reason is not clear at the present time. Since there are even fewer data on τ_e for notched specimens than there are for smooth specimens, an approximate solution can be obtained when combined stresses are applied to notched material. The procedure is to correct the vibratory component in the Goodman diagram by means of an appropriate notch-strength-reduction factor.

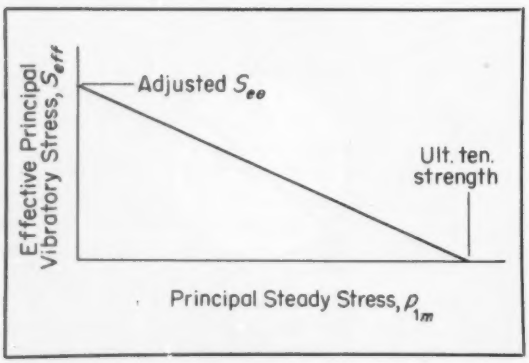


Fig. 30—Goodman diagram for biaxial fatigue stresses. This diagram uses the effective uniaxial vibratory stress as the dependent variable, and the steady major principal stress as the independent variable.

REFERENCES

1. F. B. Stulen and H. N. Cummings—"A Failure Criterion for Multi-Axial Fatigue Stresses." *Proceedings ASTM*, Vol. 54, 1954, p. 822.
2. W. N. Findley, J. J. Coleman, and B. C. Hanley—"Theory for Combined Bending and Torsion Fatigue with Data for SAE 4340 Steel." *U. S. Army Ordnance Corps, ORD, Contract DA-19-020-ORD-3520. Technical Report No.* 1, April, 1956.
3. T. Nishihara and K. Endo—"On the Theory of Fatigue Failures of Metals." *Technical Reports of the Engineering Research Institute, Kyoto University, Japan*, Vol. II, No. 8, October, 1952.
4. H. N. Cummings—"Qualitative Aspects of Fatigue of Materials," *Wright Air Development Division Technical Report* 59-230, September, 1959.

Extra copies of this series, "Preventing Fatigue Failures," may be obtained for $1.00 each from: Reader Service Dept., *MACHINE DESIGN*, Penton Bldg., Cleveland 13, Ohio.

Calculating deflections in

Stepped Shafts and Nonuniform Beams

R. BRUCE HOPKINS, Senior Engineer, John Deere Tractor Research & Engineering Center, Waterloo, Iowa

Arranged for solution on a desk calculator, this straightforward method predicts deflections at any and all points in stepped shafts and variable-section beams. Applications include simple, overhanging, and continuous beams.

SEVERAL methods are available for determining deflections in stepped shafts and variable-section beams. None is as simple as calculating by conventional beam formulas the deflections in a shaft or beam of constant cross section. Graphical methods of finding the deflections in stepped shafts are probably the most widely used.

This article explains a numerical method of carrying out the same steps as in a graphical method. If a desk calculator is available, the work can be performed rapidly with any number of digits. No drawing is necessary. Sacrifices in accuracy, such as may occur when a long shaft is diminished in scale to fit an available drafting board, are avoided.

The basic equation for small deflections of a straight beam is

$$\frac{d^2y}{dx^2} = \frac{M}{EI}$$

Two integrations are required to obtain deflections after the bending moment curve is determined.

Since the integrations are not performed over infinitely small increments of length, a shaft is first divided into convenient intervals. To simplify calculations, these intervals are chosen to begin and end at changes in cross section and preferably also at concentrated loads.

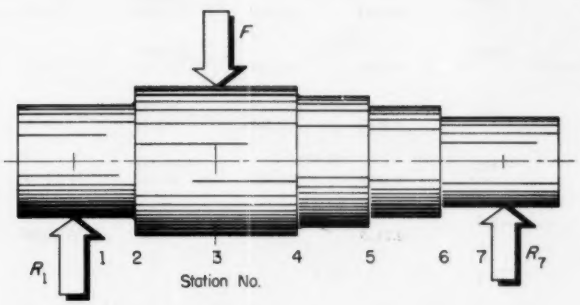
Moreover, accuracy of the calculation is increased if relatively long, uniform portions are divided into two or more intervals. A convenient way to identify the ends of intervals is by station numbers.

Numerical Method

Explanation of the method is presented by solving four typical examples. Example 1 is a simple shaft (or beam) with two concentrated loads. Those details of finding deflections that apply also to the other examples are set forth as a series of 14 steps. As each step is performed, the numerical results

Nomenclature

D = Shaft diameter, in.
F = Force or applied load, lb
I = Moment of inertia, in.^{4}
= $\pi D^4/64$ for round shaft
M = Bending moment, lb-in.
R = Reaction, with subscript to indicate station, lb
V = Vertical shear, lb
x = Co-ordinate distance along shaft axis, with Δx indicating distance between two adjacent stations, in.
y = Deflection at any distance x, mu in.
θ = Slope, mu radian



Consecutive station numbers, running from left to right, identify not only the beginning and end of each constant-section interval but also the position of each concentrated load or reaction.

Circle 14-8 on Page 19 for extra copy.

are recorded in the columns of the calculation form, which can be a standard form.

One deflection problem differs from another chiefly in the method of finding reactions and in finding the values to be entered in columns 13 and 14. These details are explained in the text describing the type of beam and loading involved.

Simple Beam

Prior to calculating tabular values for Example 1, reactions $R_1 = 1344$ lb and $R_7 = -444$ lb are found by statics. Then, steps 1 to 14 are carried out in order.

Slight variations in method occur for different problems in finding the integration constant values for column 13. In general, they are calculated by summing the deflection increment values in column 12 to obtain Σy. The sign of Σy is changed and the sum divided by the distance between the reactions to obtain the integration constant per inch of length.

For Example 1, the integration constant is $-1021.966/6 = -170.328$ mu in. per in. of length. This value is multiplied by Δx values from column 4 to obtain the integration constant for each interval. These are listed on the same lines as the average slope and deflection increments.

Deflections in Simple Beam: In column 14, zeros

Step-by-Step Procedure for Finding Shaft and Beam Deflections

1. Divide shaft (or beam) into lengths with intervals beginning at each force and change in section.
2. Label the ends of intervals with station numbers beginning at the left-hand reaction or force.
3. List station numbers on alternate lines in the first column of calculation sheet.
4. List reactions and forces in column 2 on the same lines as the station numbers at which they occur. Care should be taken to designate proper signs to forces and reactions (upward forces are considered positive in all the examples).
5. Calculate the vertical shear at each station by summing the values in column 2. Tabulate each shear value in column 3, one station below the station for which it is calculated. The last shear value should be numerically equal to but opposite in sign to the last force listed in column 2.
6. In column 4, on the same line as the station number, list the distance to preceding station.
7. Calculate bending moment at each station and list the values in column 5. Value at the first station is zero. Values at succeeding stations are obtained by summing the products of V (column 3) and Δx (column 4).
8. Calculate the moment of inertia I in bending for each interval. Place the I values in column 6 on the line between the two stations at which the interval begins and ends.
9. Multiply each I value by modulus of elasticity E and insert the EI values in column 7 on same lines as corresponding I values. Here, $E = 30{,}000{,}000$ psi.
10. Divide each bending-moment value in column 5 by the EI values in column 7 which precede and follow it. List these values in column 8.

Example 1—Simply Supported Steel Shaft with Two Concentrated Loads

1. Station Number From Left	2. Force F or Reaction R (lb)	3. Shear at Preceding Station V (lb)	4. Distance Between Stations Note 1 (in.)	5. Bending Moment M Note 2 (lb-in.)	6. Moment of Inertia I (in.^{4})	7. $\frac{EI}{10^6}$ (lb-in.^{2})	8. $\frac{M}{EI}\left(\frac{1}{\text{mu in.}}\right)$	9. Average Column 8 $\left(\frac{1}{\text{mu in.}}\right)$	10. Slope Note 3 (mu radian)
1	$R_1 = 1344$			0	0.2485	7.455	0 157.749	78.874	0
2		1344	0.875	1176	0.7854	23.562	49.909 114.079	81.994	69.015
3	−3000	1344	1.125	2688	0.7854	23.562	114.079 35.013	74.546	161.258
4		−1656	1.125	825	0.4603	13.809	59.746 −60.181	−0.218	245.122
5	2100	−1656	1.000	−831	0.4603	13.809	−60.181 −28.027	−44.104	244.904
6		444	1.000	−387	0.2485	7.455	−51.912 0.134	−25.889	200.800
7	$R_7 = -444$	444	0.875	1					178.147

are placed opposite the stations at which reactions occur because these points have zero deflection. A deflection curve is obtained by summing together the deflection increment and integration constant values from columns 12 and 13. These deflection values are placed on the same lines as the stations.

Check Calculations: Certain checks for errors can be made during the course of the calculations. The shear diagram must return to zero at the last station. Likewise, the moment diagram should become zero at the last station unless a moment is acting at that point. In many practical cases, the moment at the last station will be slightly different from zero because of rounding of the values used for reactions.

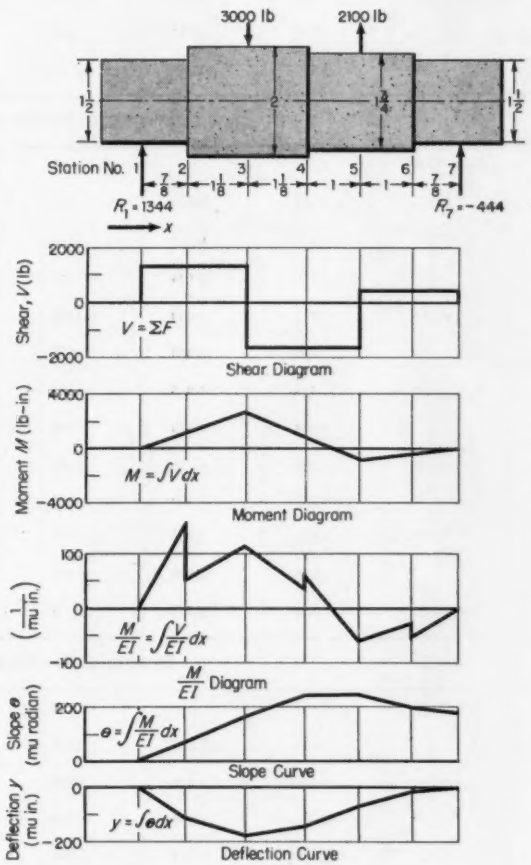
If a desk calculator is used, the bending moment values can be readily obtained by using the accumulative multiplication key. However, if a slide rule must be used, it is more convenient to insert an additional column in which to list the moment increments and then add these increments to obtain the bending moment at each station.

Modifications: When the same value of I occurs several times, it is more convenient to calculate $1/EI$ values instead of EI values because multiplication can be performed more rapidly than division on a calculator. If the entire shaft is made of the same material, division by E can be deferred until the very last operation, if desired.

If the integration constant is not accounted for in the calculations, a skewed deflection curve will

11. Obtain the average M/EI value for each interval by averaging the values on the line on which the station is listed and the following line. List the average values on the lines between stations in column 9.
12. Calculate the slope values in column 10 starting with zero at station 1. Succeeding values are obtained by summing the products of $(M/EI)_{avg}$ from column 9 and the Δx value on the next lower line of column 4. These values are listed on the same lines as the stations.
13. Average the slope values in column 10 at the beginning and end of each interval. These values are listed on the lines between stations in column 11.
14. Obtain the deflection increment values in column 12 by multiplying the average slope value in column 11 and the Δx value from the next lower line in column 4.
15. Entries for columns 13 and 14 vary depending on type of beam and loading. These are explained in the text.

11. Average Slope Note 4 (mu radian)	12. Deflection Increment Note 5 (mu in.)	13. Integration Constant (mu in.)	14. Calculated Deflection y (mu in.)	1. Station Number From Left
			0.000	1
34.508	30.194	−149.037		
			−118.843	2
115.136	129.528	−191.619		
			−180.934	3
203.196	228.589	−191.619		
			−143.964	4
245.013	245.013	−170.328		
			−69.279	5
222.852	222.852	−170.328		
			−16.755	6
189.474	165.790	−149.037		
	1021.966		0.000	7



Note No.	Symbol or Equation
1.	Δx (in.)
2.	$M = \Sigma V \Delta x$ (lb-in.)
3.	$\theta = \sum \left(\frac{M}{EI} \right)_{avg} \Delta x$ (mu radian)
4.	θ_{avg} (mu radian)
5.	$\Delta y = \theta_{avg} \Delta x$ (mu in.)

Example 2—Steel Shaft With Overhanging Loads

1. Station Number From Left	2. Force F or Reaction R (lb)	3. Shear at Preceding Station V (lb)	4. Distance Between Stations Note 1 (in.)	5. Bending Moment M Note 2 (lb-in.)	6. Moment of Inertia I (in.^{4})	7. EI / 10^6 (lb-in.^{2})	8. M / EI $\left(\frac{1}{\text{mu in.}}\right)$	9. Average Column 8 $\left(\frac{1}{\text{mu in.}}\right)$	10. Slope Note 3 (mu radian)
1	−600			0			0		0
					0.1198	3.594	−125.208	−62.604	
2		−600	0.750	−450			−60.363		−46.953
					0.2485	7.455	−140.847	−100.605	
3	$R_2 = 2269$	−600	1.000	−1050			−140.847		−147.558
					0.2485	7.455	54.997	−42.925	
4		1669	0.875	410			17.400		−185.117
					0.7854	23.562	97.103	57.252	
5	−3000	1669	1.125	2288			97.103		−120.709
					0.7854	23.562	33.570	65.336	
6		−1331	1.125	791			57.284		−47.206
					0.4603	13.809	−39.107	9.088	
7	2100	−1331	1.000	−540			−39.107		−38.118
					0.4603	13.809	16.584	−11.262	
8		769	1.000	229			30.718		−49.380
					0.2485	7.455	120.994	75.856	
9	$R_9 = 1369$	769	0.875	902			120.994		16.994
					0.2485	7.455	60.631	90.812	
10		−600	0.750	452			125.764		85.103
					0.1198	3.594	0.556	63.160	
11	600	−600	0.750	2					132.473

Example 3—Steel Shaft Supported by Three Bearings in Alignment

1	$R_1 = 1229$			0			0		0
					0.2485	7.455	144.200	72.100	
2		1229	0.875	1075			45.623		63.088
					0.7854	23.562	104.318	74.970	
3	−3000	1229	1.125	2458			104.318		147.429
					0.7854	23.562	19.777	62.048	
4		−1771	1.125	466			33.748		217.233
					0.4603	13.809	−94.508	−30.380	
5	2100	−1771	1.000	−1305			−94.508		186.853
					0.4603	13.809	−70.681	−82.595	
6		329	1.000	−976			−130.921		104.258
					0.2485	7.455	−92.288	−111.604	
7	$R_7 = 1130$	329	0.875	−688			−92.288		6.604
					0.2485	7.455	78.874	−6.707	
8		1459	0.875	588			24.955		0.736
					0.7854	23.562	94.641	59.798	
9	−3000	1459	1.125	2230			94.641		68.008
					0.7854	23.562	21.050	57.846	
10		−1541	1.125	496			35.920		133.086
					0.4603	13.809	−75.679	−19.880	
11	2100	−1541	1.000	−1045			−75.679		113.205
					0.4603	13.809	−35.196	−55.438	
12		559	1.000	−486			−65.192		57.767
					0.2485	7.455	0.402	−32.395	
13	$R_{13} = -559$	559	0.875	3					29.422

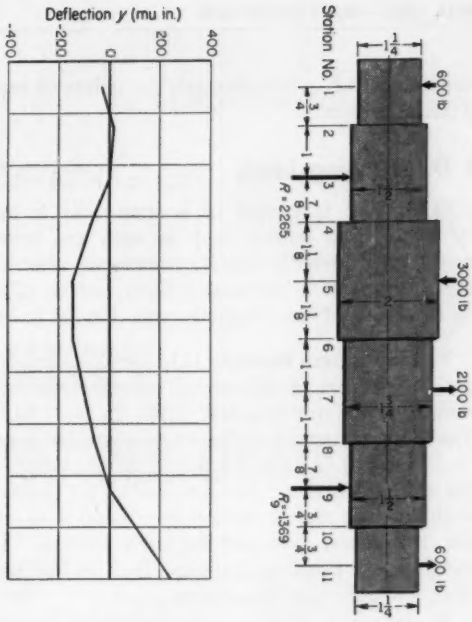
Example 4—Steel Shaft Supported by Three Misaligned Bearings

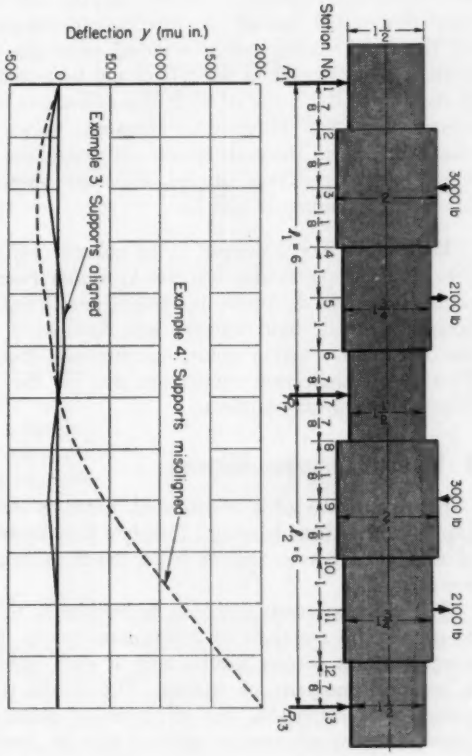
1	$R_1 = 1400$			0			0		0
					0.2485	7.455	164.322	82.161	
2		1400	0.875	1225			51.989		71.891
					0.7854	23.562	118.832	85.410	
3	−3000	1400	1.125	2800			118.832		167.977
					0.7854	23.562	42.440	80.636	
4		−1600	1.125	1000			72.420		258.693
					0.4603	13.809	−43.452	14.484	
5	2100	−1600	1.000	−600			−43.452		273.177
					0.4603	13.809	−7.242	−25.347	
6		500	1.000	−100	0.2485	7.455	45.339	15.962	
							−13.414		247.830
7	$R_7 = 788$	500	0.875	338			45.339		261.796
					0.2485	7.455	196.381	120.860	
8		1288	0.875	1464			62.132		367.549
					0.7854	23.562	123.670	92.901	
9	−3000	1288	1.125	2914			123.670		472.062
					0.7854	23.562	41.931	82.800	
10		−1712	1.125	988			71.551		565.212
					0.4603	13.809	−52.432	9.560	
11	2100	−1712	1.000	−724			−52.432		574.772
					0.4603	13.809	−24.333	−38.382	
12		388	1.000	−336			−45.071		536.390
					0.2485	7.455	0.402	−22.334	
13	$R_{13} = -388$	388	0.875	3					516.848

11. Average Slope Note 4 (mu radian)	12. Deflection Increment Note 5 (mu in.)	13. Integration Constant (mu in.)	14. Calculated Deflection y (mu in.)	1. Station Number From Left
			−34.647	1
−23.476	[+]17.607	[−]64.076		
			11.822	2
−97.256	[+]97.256	[−]85.434		
			0.000	3
−166.338	−145.546	74.755		
			−70.791	4
−152.913	−172.027	96.113		
			−146.705	5
−83.958	−94.453	96.113		
			−145.045	6
−42.662	−42.662	85.434		
			−102.273	7
−43.749	−43.749	85.434		
			−60.588	8
−16.193	−14.169	74.755		
	−512.606		0.000	9
51.048	38.286	64.076		
			102.362	10
108.788	81.591	64.076		
			248.029	11

			0.000	1
31.544	27.601	−108.972		
			−81.371	2
105.258	118.415	−140.108		
			−103.064	3
182.331	205.122	−140.108		
			−38.050	4
202.043	202.043	−124.540		
			39.453	5
145.556	145.556	−124.540		
			60.469	6
55.431	48.502	−108.972		
	747.239		0.000	7
3.670	3.211	−53.592		
			−55.381	8
34.372	38.668	−75.332		
			−92.045	9
100.547	113.115	−75.332		
			−54.262	10
123.146	123.146	−66.962		
			1.922	11
85.486	85.486	−66.962		
			20.446	12
43.594	38.145	−53.592		
	401.771		0.000	13

			0.000	1
35.946	31.453	−168.551		
			−137.098	2
119.934	134.926	−216.709		
			−218.881	3
213.335	240.002	−216.709		
			−195.588	4
265.935	265.935	−192.630		
			−122.283	5
260.504	260.504	−192.630		
			−54.409	6
254.813	222.961	−168.551		
	1155.781		0.000	7
314.672	275.338	−133.795		
			141.543	8
419.506	472.282	−172.023		
			441.802	9
518.637	583.467	−172.023		
			853.246	10
569.992	569.992	−152.909		
			1270.329	11
555.581	555.581	−152.909		
			1673.001	12
526.619	460.792	−133.795		
	2917.452		2000.000	13





Note No.	Symbol or Equation
1.	Δx (in.)
2.	$M = \Sigma V \Delta x$ (lb-in.)
3.	$\theta = \sum \left(\frac{M}{EI} \right)_{avg} \Delta x$ (mu radian)
4.	θ_{avg} (mu radian)
5.	$\Delta y = \theta_{avg} \Delta x$ (mu in.)

result in which a line through the points of support is not horizontal.

Overhanging Loads

Example 2 is typical of a shaft that is loaded by forces both outside and between the bearings. Reactions are readily found by moments, after which the columns of a calculation form can be filled in by repetition of the foregoing steps, 1 to 14 inclusive.

Variations from Example 1: In summing the deflection increments of column 12 only those from stations 3 and 9 are included. Thus $\Sigma y = -512.606$. The sign is changed so that the integration constant $= 512.606/6 = 85.434$ mu in. per in., where 6 is the distance between the reactions. This constant is multiplied by the Δx values in column 4 to obtain the integration constant for each interval. These products are listed on the same lines as the average slope and deflection increments.

A change in signs of the deflection increments and integration constant values for the left-hand force is required because the direction of integration for the overhanging load is reversed when the integration is performed to the left of the first reaction. Accordingly, the signs of both the deflection increments and the integration constant values are changed for the intervals which constitute the left-hand overhang. These altered signs are shown in brackets in columns 12 and 13.

Deflections For Example 2: In column 14, zeros are placed opposite the stations at which reactions occur. Next, the deflection increment and integration constant values, both upward and downward from the left-hand reaction point, are summed together. Finally the deflection values are put on the same lines as the station numbers.

Three Bearings—Aligned

Representative of a continuous beam is a shaft supported by three bearings. Example 3 is illustrative of the calculation procedure when the three bearings are aligned.

The three-moment equation is frequently utilized to obtain the reactions of continuous beams. However, it yields correct results only if each span has a uniform moment of inertia. The elastic-weight principle is applicable for all cases of continuous beams but an alternative method can be used for beams with three supports.

This principle consists of calculating a deflection curve as a simple beam with one support omitted and then calculating another deflection curve with an assumed force acting in place of the omitted support. The force required to make the deflection at this support zero can be obtained by interpolation or extrapolation.

In Example 3, if $R_{13} = 0$, the deflection at station 13 is 6543 mu in. If R_{13} is assumed to be -388 lb, the deflection at the same point is 2000 mu in. and by extrapolation it is found that R_{13} must equal -559 lb for zero deflection at that point. With one reaction known, the other reactions can be determined by summing moments about the reaction points. Also, steps 1 through 14 apply for Example 3 as for Example 1.

Variations From Example 1: There are two spans to consider. Integration constant values for the first span are obtained by summing the deflection increments from R_1 to R_7, where $\Sigma y = 747.239$. Again the sign of Σy is changed and the sum is divided by the length of the span to obtain the integration constant per in. of length. Thus, the integration constant is $-747.239/6 = -124.540$ mu in. per in. This constant is multiplied by the Δx values in the first span from column 4 to obtain the integration constant for each interval, column 13.

This procedure is repeated for the second span. Here, $\Sigma y = 401.771$ over the span R_7 to R_{13} and the integration constant becomes $-401.771/6 = -66.962$ mu in. per in.

Deflections For Example 3: In column 14, zeros are placed opposite the stations at which reactions occur. Then, a deflection curve is obtained by summing together the deflection increment and integration constant values from columns 12 and 13.

Three Bearings—Misaligned

The shaft of Example 3 has a negative reaction R_{13}. If the shaft is fitted with bearings which have clearance, it must deflect to make contact at the right-hand bearing. This deflection resulting from misalignment alters the reactions.

The reactions can be found in the same manner as for a beam with the supports in alignment. However, the interpolation or extrapolation is performed to find the force required to produce the amount of misalignment at the support instead of for zero deflection.

For Example 4, suppose the reactions are found for the misalignment caused by bearing clearances of 0.002 in. Steps 1 to 14 are carried out just as for the simple beam.

Variations From Example 1: For the first span from R_1 to R_7, $\Sigma y = 1155.781$ so that the integration constant is $-1155.781/6 = -192.630$ mu in. per in.

In the second span where the misalignment occurs, the upward deflection is subtracted from Σy before the integration constant is calculated. If a deflection at the support is downward, the amount of misalignment is added to Σy. Hence, $\Sigma y = 217.452$ so that the integration constant is $(-2917.452 + 2000.000)/6 = -152.909$ mu in. per in.

Deflections For Example 4: In column 14, zeros are placed opposite the reaction points where the supports are aligned and the amount of the misalignment is placed opposite the station where the deflection is permitted. Deflection increments and integration constant values from columns 12 and 13 are summed to obtain the deflection curve.

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

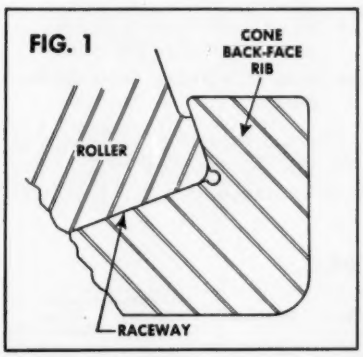
BEARING BRIEFINGS

BEARING GEOMETRY MAKES OR BREAKS BEARING PERFORMANCE

To develop high capacity and optimum performance in a tapered roller bearing, it is essential that roller alignment be accurate. Correct roller alignment, in turn, depends on a critical geometric relationship between the cone back-face rib, and the cone raceway.

Perfection in this geometric relationship compels the rollers to align themselves perfectly with respect to the bearing geometry, and each roller shares equally in the work that is imposed. Figure 1 diagrams the important elements involved.

When this rib-to-raceway relationship is incorrect (because of either faulty bearing design or manufacturing inaccuracies), rollers experience misalignment and begin to skid and skew under



load. As engineers know, poor performance and premature bearing failure are inevitable under these conditions.

In the design and manufacture of Bower tapered roller bearings, Bower engineers take great care to generate and hold an exact face angle on the cone back-face rib. In practice, this means that Bower

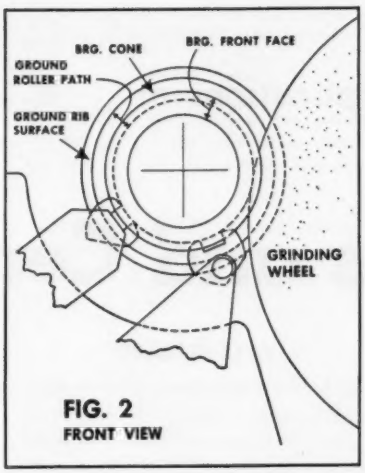
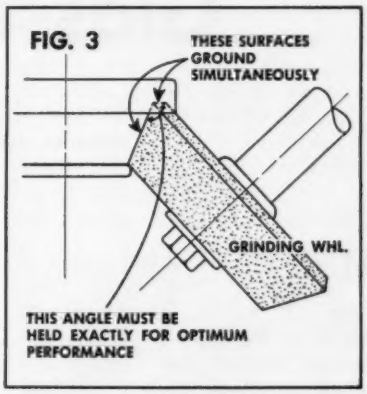


FIG. 2
FRONT VIEW

bearings are designed for maximum life and optimum performance under any operating conditions. It means that Bower bearings retain accurate roller alignment under all speeds and loads up to the maximum for which the bearing is rated.

It's one thing to develop proper bearing design on paper, but quite another to carry it out consistently in manufacture. To this end, Bower engineers were instrumental in the design and development of a unique centerless grinder on which Bower precision grinds each bearing's cone raceway and rib-face simultaneously. The results obtained from these machines invariably meet or surpass Bower's exacting requirements and assure perfect roller alignment.

Figures 2 and 3 are front and top views which illustrate Bower's technique of centerless grinding rib-faces and cone raceways together. As a result, every component in a Bower bearing is perfectly concentric about its rolling axis.



★ ★ ★ ★

When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Circle 281 on Page 19

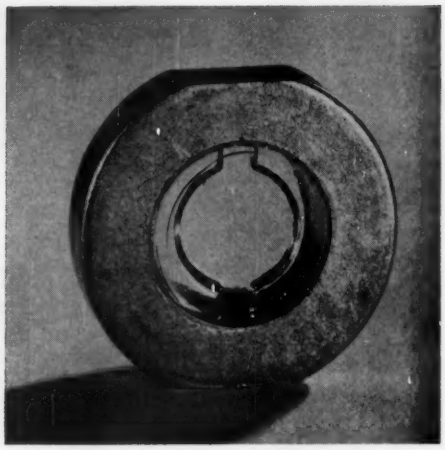


Fig. 1—High compression strength of glass enables a window to be hot-molded into a sight-glass fitting. On cooling to room temperature, the brass fitting contracts around the window, reinforcing it and strengthening it as well as making a seal. This unit can be used up to 1000 psi.

Properties and applications of

Glasses and Ceramics

J. R. BLIZARD

Manager, Technical Products Div., Corning Glass Works, Corning, N. Y.

MECHANICAL characteristics of ceramics differ widely from those of metals. Brittleness, of course, is the most important distinction between the ceramics and metals. A ceramic material does not plastically flow or creep before failure. It breaks in pure tension, never in shear, and rarely in compression.

Design Guides

In the design of load-bearing ceramic parts, bear these points in mind:

- Apply the load in compression if possible.
- Use simple shapes. Avoid sharp corners, sudden changes of section, holes in tension zones.
- Keep ground or abraded surfaces out of tension unless they are given a fine smooth finish.
- Provide resilient pads at load-bearing contact zones with metal parts.
- Avoid point loading and stress concentrations.

Thermal expansion coefficients of ceramics are generally much lower than for metals. It is thus important

Table 1—Typical Properties of Bonded Ceramics

Property	Alumina 85%	Alumina 96%	Alumina 99%	Beryllia 96%	Steatite	Forsterite	Silicon Carbide — Silicious Bond	Silicon Carbide — Silicon-Nitride Bond
Tensile strength, in flexure (psi)	43,000	48,000	60,000	32,000	20,000	20,000	2000*	5600*
Modulus of elasticity (10^6 psi)	32	42	50	46	14	14	17	17
Hardness:								
moh scale	9	9	9	9	7.5	7.5	9.6	9.6
Knoop	....	1880	....	....	....	....	....	....
Max working temp (F)	2550	3100	3140	2200	1800	1800	2750	3000
Thermal expansion coefficient, at 72 to 750 F (10^{-7} in./in./deg F)	35	40	40	51	46	55	24.5	24.5
Thermal conductivity, at 72 F (Btu/hr/sq ft/deg F/ft)	8	12	17	157	1.4	1.9	8.5	8.8
Specific gravity	3.40	3.72	3.90	2.90	2.6	2.8	2.57	2.87
Water absorption (per cent)	Nil	Nil	Nil	Nil	0 to 0.02	0 to 0.02	13	8

*at 2500 F.

Circle 14-9 on Page 19 for extra copy.

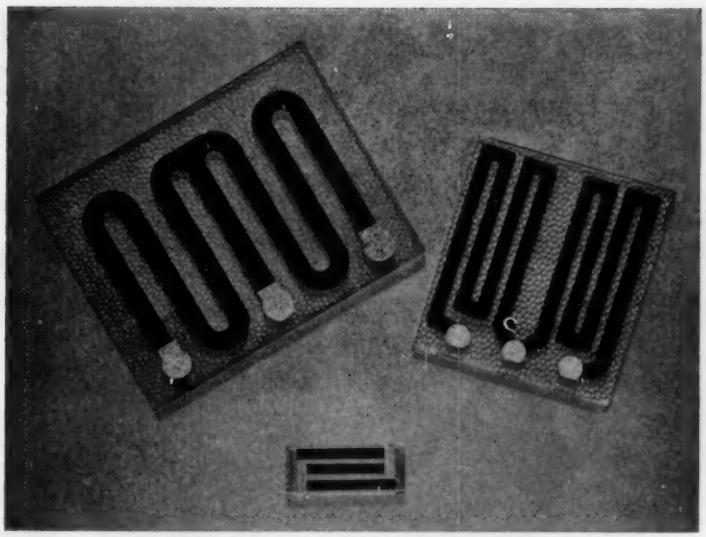


Fig. 2—A base of borosilicate glass and a semiconductor of tin oxide comprise small electric heaters for localized heating or defrosting. The smallest shown is the size of a postage stamp.

to allow for mismatches in ceramic-metal assemblies for hot service. Where clearances are tight, the metal part can be made thin enough so it deforms instead of overstressing the ceramic. If the metal piece clamps and compresses the ceramic, the dangers of overstressing are also greatly reduced.

Thermal endurance of a ceramic part is potentially much higher than for metals. Failure is unlikely, within the recommended operating limits, unless the part is subjected to excessive thermal stresses. These may be steady state or transient stresses.

All thermal stresses can be minimized in the following ways:

- Choose a ceramic with low thermal expansion.
- Use thin sections.
- Reduce mechanical constraint to a minimum. Let the part "float" if possible.
- Avoid localized hot or cold areas in the part. Expose the entire ceramic area to heat rather than shrouding the edges.

Certain ceramics have such low expansion coefficients that they are practically immune to thermal shock failure.

Bonded Ceramics

There are certain ceramics whose properties and availability make them of special interest to the product designer. Their mechanical properties appear in Table 1.

High-alumina ceramics can be compared to the high-alloy steels in the metal family. Their mechanical properties are among the best in the ceramic group. Although they are relatively expensive, they are generally used for exceptional strength, abrasion resistance, heat resistance, or chemical purity.

Beryllia, BeO, is one of the newest ceramic materials. Its cost is much higher than the other ceramics. Besides being hard, dense, and thermally resistant like alumina, beryllia has surprisingly high thermal conductivity. At room temperature it is higher than aluminum and about 10 times higher than alumina. The advantage is lessened at elevated temperatures but even at 1000 F beryllia exceeds alumina by a factor of 6.

Applications for beryllia are presently limited to a diameter of about 4 in. and a height of 8 to 10 in. Extruded sections can be made in diameters up to 1 in. and lengths up to 24 in.

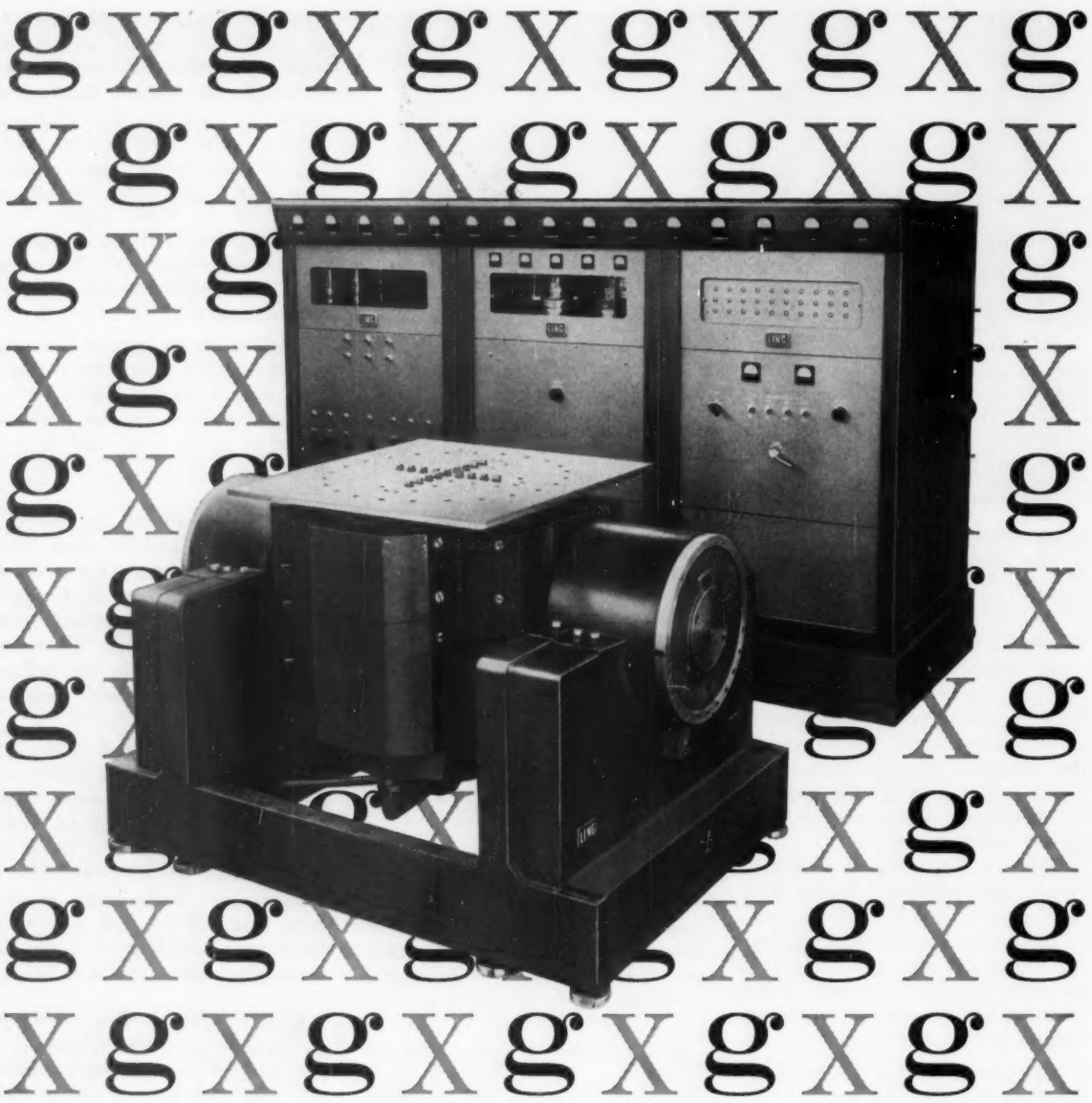
Steatites, based on the composition $MgSiO_3$, are the most commonly used ceramics for low-cost molded parts such as small appliance insulators, heater wire supports, and tube sockets. They can easily be machined in the unfired state. Tapped holes and threaded exteriors are feasible.

Alumina, beryllia and steatite can all be metallized with a tightly adhering film to which metal parts can be soft or hard soldered. Bond strengths of 3500 psi are easily attained. With special procedures, it is possible to make bonds to alumina and beryllia that will withstand loads of 12,000 psi. These latter coatings can be brazed at 1000 C.

Silicon carbide, long known as an abrasive grain and refractory, is now molded into complex mechanical parts and bonded either with a silicious material or with silicon nitride. It is not usually made into parts less than ¾ in. or over 30 in. in size. Wall thicknesses should be at least 3/16 in. and preferably ¼ in.

Table 2—Typical Properties of Glasses and Glass-Ceramics

Property	Glasses					Glass-Ceramics	
	Lime	Lead	Borosilicate	96 Per Cent Silica	Fused Silica		
Tensile strength, in flexure (psi)	7000	7000	8000	8000	8000	20,000	20,000
Modulus of elasticity (10^6 psi)	10.0	8.2	9.5	9.6	10.4	17.3	12.5
Hardness—Knoop	470	400	470	500	550	700	700
Max working temp (F)	500	500	700	1800	1800	1300	1300
Thermal expansion coefficient (10^{-7} in./in./deg F)	48	49	18	4	3	32	8
Thermal conductivity, at 72 F (Btu/hr/sq ft/deg F/ft)	0.6	0.4	0.6	0.8	0.8	2.	1.
Specific gravity	2.48	3.05	2.23	2.18	2.20	2.61	2.50
Water absorption	0	0	0	0	0	0	0
Transparency or color	Clear	Clear	Clear	Clear	Clear	White opaque	White opaque



ONLY LING'S NEW X-ARMATURE SHAKER TAKES 75 pound packages to 100 "g"... 208 pounds to 60 "g"

Ling brings you another important development in vibration testing—the revolutionary L-200 Shaker with the capability needed to test heavier packages at higher "g" levels than ever before. The L-200, with a force rating of 20,000 pounds, is designed on a new Ling concept. The unique "X" design armature develops uniform force on two rows of mounting studs which are set in an "X" pattern on the big table. An exceptionally low stray field—less than 3 gauss at table level—protects sensitive guidance packages. The armature weight is only 125 pounds. This, plus efficient coupling, lets you take a 75-pound package up to 100 "g" or a 208-pound package to 60 "g"—a performance no other shaker can match. The L-200's interior is completely sealed off to screen out all chips, dust or contaminants, and is designed to allow environmental test adaptability. For more details on the advantages of the L-200, write to Department MD-761 at the address below.

LING-TEMCO ELECTRONICS, INC.

LING ELECTRONICS DIVISION

1515 SOUTH MANCHESTER, ANAHEIM, CALIFORNIA • PRospect 4-2900

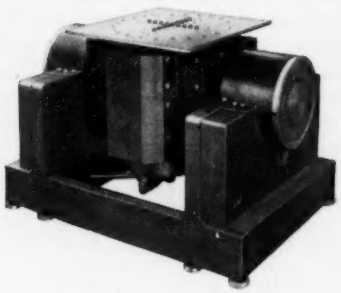
Circle 282 on Page 19

LING ELECTRONICS

Ling engineers think big—and far ahead—to anticipate your needs in vibration testing equipment. The L-200 Shaker shown at the left is another example of sound Ling engineering at work—for this big shaker has every possible advance built in to improve testing accuracy and convenience. The L-200 takes you into the realm of high "g" testing with heavier-than-ever payloads.

Ling's newly designed hydrostatic bearings dampen cross axial movement of the shaker armature.

Gauss level during operation is exceptionally low, less than 3 gauss at table top. The control of the shaker angle is simple since rotation is hydraulically actuated! A visual 200° protractor has been built into each trunnion by Ling.



Check the capabilities of Ling's new L-200, 20,000-pound shaker:

VECTOR	MAXIMUM LOAD
10 "g"	1875 lbs.
20 "g"	875 lbs.
60 "g"	208 lbs.
100 "g"	75 lbs.

Whatever your needs in high power electronics—vibration testing, acoustics or sonar—you'll find you can rely on Ling for the soundest design, the most advanced engineering.

LING-TEMCO ELECTRONICS, INC.
LING ELECTRONICS DIVISION
HIGH POWER ELECTRONICS FOR
VIBRATION TESTING • ACOUSTICS • SONAR

Titanium di-boride, a new material, is not yet in general commercial use. Extremely temperature resistant, it can support a 35,000-psi tensile stress at 3600 F. Its elastic modulus is twice that of steel and its hardness is considerably greater than alumina. It is an excellent electrical conductor and has thermal conductivity about equal to alumina. Like silicon carbide, it is inert to molten aluminum and zinc.

Titanium di-boride is molded from powder and can be machined before final processing. The largest pieces made to date are cylinders 6 in. diam and 20 in. long, weighing 100 lb each, and cylinders 14 in. diam and 10 in. long weighing 260 lb each.

Glass and Glass-Ceramics

Glasses and glass-ceramics are very different in structure but keep the essential mechanical characteristics of bonded ceramics. Typical properties are listed in Table 2.

Borosilicate glass is distinguished by its low thermal-expansion coefficient—about 1/4 to 1/5 that of most metals and 1/3 that of the lime and lead glasses—and by its hard surface and excellent chemical durability.

The 96 per cent silica glasses, known by the trade name "Vycor," are colorless and quite similar to fused silica. Thermal-expansion coefficient of Vycor glass is so low that it is virtually immune to thermal-shock damage. Heat resistance is much higher than for any other glasses. They can be used continuously at temperatures of 1600 F—under some conditions, as high as 2000 F. These glasses have exceptionally good ultraviolet and infrared transmission.

There are few limitations on shapes and sizes. Thickness is usually limited to 3/8 in. but it is possible to produce 1-in. slabs. Cost is much higher than that of the borosilicate glasses.

Applications

It has been noted that all the ceramics have high compressive strength. This property is used in a glass capsule that carries an explosive perforating charge into an oil well. It must resist crushing loads of over 10,000 psi before it is destroyed. Glass capsules of this type can actually resist external pressures over 30,000 psi without even leaking at the cemented joint. When destroyed, the glass pulverizes into particles so fine that they are carried out in the oil stream without plugging orifices or valves.

High compressive strength is also used in a sight-glass fitting, Fig. 1.

Electric heating elements can be made by coating a borosilicate glass with a hard semiconductor film consisting essentially of tin oxide, Fig. 2. Resistances can be varied from 6 to 100 ohms per sq in. and the surface can be operated continuously at 650 F. Maximum energy dissipation is 15 watts per sq in. in still air.

The 96 per cent silica glasses as well as fused silica are used to make tubular electric heaters, thermocouple protecting tubes, ultraviolet lamps, and welding-torch tips.

Tubes, cylinders, rods, laboratory flasks and ingots up to about 20 in. diam are made by fusing pure quartz crystals or silica sand. Another process, based on the synthesis of SiO_2 is used to produce slabs and ingots of pure clear silica in sizes ranging upward to 12-in. thick and 60 in. diam. Ultra-low-expansion coefficient of this material makes it possible to obtain amazingly accurate surfaces.

The glass-ceramics, tradenamed Pyroceram, are stronger than the glasses, better heat conductors and higher in hardness and elastic modulus. At present the Pyroceram materials are available in pressed, blown, and spun shapes.

ASME Paper No. 61-MD-6, "What Do Glasses and Ceramics Offer the Design Engineer?," presented at the Design Engineering Conference, Detroit, May, 1961, 8 pp.

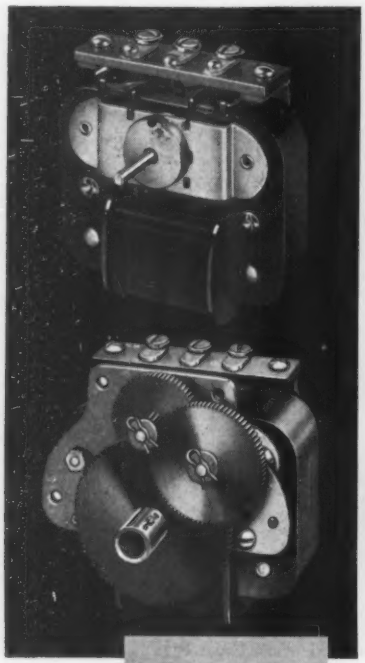
management

Cost of Support Functions In R & D Laboratories

H. T. Thompson, General Electric Co., Schenectady, N. Y.

Data on the cost of the commonly recognized supporting functions of research and development laboratories and presentation of these data

High-torque, fast-reversing Barber-Colman quality motors for low-cost servo systems utilizing either transistor or vacuum tube control



THE MARK OF QUALITY

BARBER COLMAN

FAST-REVERSING LOW-INERTIA ROTORS

HIGH STARTING TORQUE

ELECTRODYNAMIC BRAKING

ADAPTABLE TO SPLIT-PHASE CAPACITOR OPERATION

AVAILABLE WITH 2-PHASE OR ELECTRONIC CONTROL WINDINGS

AVAILABLE WITH OPEN OR CLOSED GEAR REDUCTIONS

a-c small motors

Barber-Colman shaded pole reversible motors are adaptable to a variety of electronic control circuits to meet the many different requirements of applications demanding a compact, powerful, fast-reversing motor. In many servo systems they satisfactorily replace motors costing twice as much. Ratings are from .00015 to .04 hp. For further information write for literature on use of these motors in servo systems with transistor or vacuum tube amplifiers.

THE WIDE LINE OF BARBER-COLMAN A-C MOTORS includes unidirectional, synchronous, and reversible types . . . with or without reduction gearing . . . open or enclosed. Stator and rotor sets also available. Write for quick reference file.

BARBER-COLMAN COMPANY

Dept. S, 1273 Rock Street, Rockford, Illinois

in a form that would be useful to managers as a framework within which they could compare their own costs.

Data are given for the mean cost of each of fifteen supporting functions for ten research and development laboratories. Data are also given for the mean number of employees engaged in the work of each of the fifteen functions for the ten laboratories. The degree to which these mean costs and mean number of employees are useful as a reference framework is discussed.

AIEE Conference Paper No. CP 61-800, *"Costs of Supporting Functions of Research and Development Laboratories," presented at the AIEE Summer General Meeting, Ithaca, N. Y., June,* 1961, 13 *pp.*

Cost of Small Tolerances And Smooth Finishes

William L. Gilbert, manager, Machining Development Service, General Electric Co., Schenectady, N. Y.

Design-versus-cost data to guide the designer and manufacturer in the choice of the most economical method for producing holes. The data are the relative costs of materials, processes, surface finishes, tolerances, and cutting conditions.

ASME Paper No. 61-MD-12, *"Cost and Value of Small Tolerances and Smooth Finishes," presented at the Design Engineering Conference, Detroit, May,* 1961, 7 *pp.*

processes

Design for Powder Metallurgy

Paul J. Failla, general superintendent, Machine Shops, Johnson Bronze Co., New Castle, Pa.

Design consideration and techniques for powder-metallurgy fabrication. Advantages of powder metallurgy include:

- Special mechanical properties such as controlled porosity, mass, weight, density, finish and accuracy of geometric shapes, noise damping, performance to wear and life, and space reductions.
- Special alloys obtainable only by powder metallurgy such as carbides.
- Unusual complex precision geometric shapes that would be almost impossible or impractical to obtain by other methods.

- Cost reduction through simplification of inspection, scrap, machining, and assembly problems.

ASME Paper No. 61-MD-16, "Designing with Powder Metallurgy to Improve Quality and Reduce Costs," presented at the Design Engineering Conference, Detroit, May, 1961, 8 pp.

mechanical

Selection of Machine Drives

George W. Younkin, chief development engineer, Giddings and Lewis Machine Tool Co., Fond du Lac, Wis.

Economic and technical considerations in the application of electrical, mechanical and hydraulic machine drives.

Application of a machine as to its use will determine to some extent which drive should be used. Four possible areas of machine application are: As a general use machine, a process-type regulated drive, a numerically controlled contouring drive, and a numerically controlled point-to-point machine drive.

ASME Paper No. 61-MD-4, "Which Drive—Electrical, Mechanical, or Hydraulic?", presented at the Design Engineering Conference, Detroit, May, 1961, 12 pp.

Which Fastener?

John W. Stouthenburg, vice president, Robin Products Co., Warren, Mich., and Kenneth D. Ringland, chief engineer, New England Div., Central Screw Co., Keene, N. H.

An evaluation of the engineering and production problems pertaining to the application, function, design and cost analysis of the fastener, both standard and custom engineered types.

ASME Paper No. 61-MD-15, "Which Fastener Should We Choose," presented at the Design Engineering Conference, Detroit, May, 1961, 8 pp.

bearings

Nonrotating Journal Bearings Under Sinusoidal Loads

R. M. Phelan, associate professor of mechanical engineering, Sibley School of Mechanical Engineering, Cornell University, Ithaca, N. Y.

Performance characteristics of a journal bearing in which the squeeze film is developed by a varying load

Type HYLM (1" diameter) Barber-Colman quality permanent magnet motor for precision applications . . . meets military specifications

THE MARK OF QUALITY
BARBER COLMAN

typical applications

PROGRAM SWITCHES
TUNING MECHANISMS
ELECTROMECHANICAL ACTUATORS
COOLING FANS AND BLOWERS
TIMING MECHANISMS
SWITCHING DEVICES

d-c small motors

Type HYLM 1" diameter precision-made Barber-Colman motor is available in three lengths and can be supplied for use on any voltage from 6 to 115 volts d-c. Square brushes, retained by a constant-pressure spring, ensure long brush life. Dynamic braking can be employed if desired. This motor is equipped with R2 ball bearings, has an explosion-proof housing, and meets environmental requirements of MIL-M-8609 (ASG). A quality motor throughout . . . lightweight, compact, efficient. Ask for Bulletin F-10421.

WRITE FOR NEW QUICK REFERENCE FILE
on the complete line of Barber-Colman electrical components, a-c and d-c small motors, tach generators, blowers, gearheads, relays.

BARBER-COLMAN COMPANY
Dept. S, 1873 Rock St., Rockford, Illinois

Circle 284 on Page 19

with zero angular motion of the load, the journal, and the bearing:

- Except for very lightly loaded bearings, the load is supported almost entirely by positive pressures developed in the half of the bearing in which the film thickness is decreasing.
- The most critical factor in determining the behavior is the filling up of the space on the unloaded side of the bearing.
- Stefan's solution for approaching flat plates cannot be applied directly to predicting the behavior of an actual bearing. A piston with rounded ends in a cylinder is a more appropriate model than approaching flat plates.
- The modification of Stefan's equation by an area factor k results in an analytical expression that provides considerable insight into basic behavior characteristics, permits a reasonable prediction of behavior for sinusoidal loads, and offers a method for estimating the behavior under any type of varying load.
- In comparison with wedge film, squeeze film is relatively ineffective in supporting a load in the critical region of thin films.

ASME Paper No. 61-LUBS-6, *"Non-Rotating Journal Bearings under Sinusoidal Loads," presented at the Lubrication Symposium, Miami, Fla., May,* 1961, 16 *pp.*

materials

Recent Developments In Design and Fabrication With High-Strength Steels

R. H. Marvin, chief engineer, Space Atomics Section, The Budd Co., Philadelphia, Pa.

Design and fabrication of several different types of structures which utilize high-strength steel in sheet form. Discussion is limited to cold-reduced materials and precipitation-hardenable materials which lend themselves to the type of fabrication in which resistance and fusion welding are used extensively.

ASME Paper No. 61-MD-8, *"Impact of Recent Developments in High-Strength Steels on Structural Design and Fabrica-*

WATERMAN

Series 190

FLOW REGULATORS

Constant Speed Operation

regardless of load!

At a cost comparable to an ordinary restrictor or needle valve, you can have pressure-compensated flow control in your hydraulic circuits.

Rated for pressures to 3000 p.s.i.

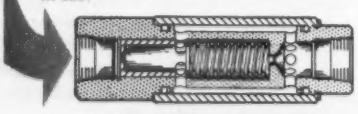
Wide range of sizes available—¼" to 1½" N.P.T.F. and ¼" to 1" S.A.E. tube.

Flows to 100 g.p.m. can be controlled.

Factory-calibrated and tested to ±10% tolerance. Closer tolerance available.

Require little more space than pipe or tube in which installed.

Trouble-free in operation—tens of thousands in use.



Unit senses pressure drop across precise orifice and reacts to control flow with desired limits.

Send today for new Catalog 1002.

MEMBER NFPA

W-8108

WATERMAN HYDRAULICS CORPORATION

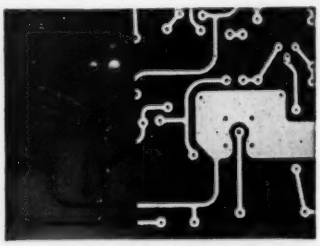
725 Custer Ave., Evanston, Ill.

Circle 285 on Page 19

Straits Tin Report

Chemical tinning enhances the solderability of the conductive paths of printed circuits. Pure tin is deposited only on metal surfaces, including exposed edges; dielectric properties are unchanged.

The new process, using "CUPOSIT LT-26," made by Shipley Co., Inc., Wellesley, Mass., is not a substitute for electrodeposited tin, but it affords protection to the printed circuit board, thereby increasing storage life. "CUPOSIT LT-26" operates at temperatures lower than hot tin dipping, requires no electricity, contains no cyanide.



Bright side of printed circuit shows results of immersion in new chemical tinning process.

Tin Developments

• *Stronger titanium* results from addition of 15% tin. Ultimate tensile strength increases 90% at room temperature.

• *High-temperature brazing filler* metal alloys of tin, nickel, chromium, silicon keep joints strong after long exposure at high temperatures.

• *Low-melting quaternary* alloys of tin, indium, lead, silver are used for cryogenic circuits.

Free Bulletin

Write today for a free subscription to TIN NEWS—a monthly bulletin on tin supply, prices and new uses.

The Malayan Tin Bureau

Dept. T-29G, 2000 K Street, N.W., Washington 6, D.C.

Circle 286 on Page 19

tion," presented at the Design Engineering Conference, Detroit, May, 1961, 12 pp.

New High-Strength Steels

R. A. Lula, chief research metallurgist, Stainless Steel, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

Mechanical properties and fabricating characteristic of newly developed precipitation-hardening stainless steels, cold-rolled metasable austenitic stainless steels and low-alloy hardenable stainless steels.

ASME Paper No. 61-MD-7, "Recent Developments in High Strength Steels," presented at the Design Engineering Conference, Detroit, May 1961, 8 pp.

Strain Strengthening Of Stainless Steel

W. Hammer Jr., Space Atomics Dept., Budd Co. Philadelphia; L. Stemann, Missiles and Space Vehicles Dept., General Electric Co., Philadelphia; and E. E. Weismantel, Technical Div., Beryllium Corp., Reading, Pa.

Development of high-strength austenitic cold-worked bars with uniform properties. Tensile cold-straining procedures were used to obtain this strength improvement. This process can achieve 100,000-psi tensile yield strength which could be raised with additional developmental effort. Compressive yield strength is estimated to be 70 per cent of the cold-strained tensile yield strength. Machining, forming, and welding experiments indicate that it is no more difficult to fabricate cold-strained austenitic bar materials than other austenitic materials now in use.

ASTM Preprint No. 83, "Strain Strengthening of Type 304 Stainless Steel," to be presented at the Sixty-fourth Annual Meeting of the American Society for Testing Materials, Atlantic City, N. J., June 25-30, 1961, 9 pp. Preprint price, 30 cents.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

ASTM—American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

KLIXON MOTOR CONTROLS COVER
ENTIRE SPECTRUM OF PROTECTION

This snap-acting on-winding protector (9850 type) is typical of the built-in protection KLIXON motor controls offer to prevent overheating and burnout for all types of AC motors. This precision-calibrated, miniature protector is attached directly to motor winding, and can be dipped and baked as part of it. Responsive to both current and temperature, it provides positive make and break action, vibration resistance, and the dependability of all KLIXON protectors.

Ranging from the simplest circuit breaker to complete motor protection . . . from the end-bell mounted, 3-phase protector (see photo below) to the on-winding 9850 type protector above, the KLIXON motor protector spectrum is the most comprehensive available to electric motor manufacturers and their customers. The spectrum brings KLIXON's wealth of application knowledge and manufacturing experience to the manufacturer . . . lets specific service conditions determine protection needs.

How KLIXON Motor Protector Spectrum Works:

As level of protection increases . . .

- Motor adaptability to a variety of applications increases.
- The protected motor is affected less by high or low ambient, or other external conditions.
- Reliability and accuracy increase.
- Overall application testing costs decrease.
- You get greater protection against motor failures due to failure of allied components.

Find out how the KLIXON SPECTRUM OF MOTOR PROTECTION can save you money. Request complete Motor Controls catalog and location of nearest KLIXON field engineer by writing:

METALS & CONTROLS INC.
3207 FOREST STREET • ATTLEBORO, MASS.
A CORPORATE DIVISION OF
TEXAS INSTRUMENTS
INCORPORATED

Circle 287 on Page 19

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Neoprene Adhesive

Latest technical data on SP-134 light-colored, heat-reactive phenolic resin for industrial and general-purpose elastomer adhesives are given in "Schenectady Presents SP-134." Included are pictures and graphs depicting tensile shear, peel back, and prereacting resin test data. 4 pages. Schenectady Varnish Co. Inc., Schenectady 1, N. Y.

Circle 501 on Page 19

Medium-Duty Casters

Two casters, one swivel and one rigid, for industrial and institutional equipment, have carrying capacities to 2500 lb per unit. Available with a variety of wheel types from 3 through 8 in. diam, units are described in new bulletin with cutaway and line drawings and tables of specifications. 4 pages. Payson-Harris & Reed Inc., 2916 W. Jackson Blvd., Chicago 12, Ill.

Circle 502 on Page 19

Industrial Felts

Ready reference index which alphabetically lists hundreds of applications of industrial felts, along with the proper type to use, is a feature of "Comparative Properties of Industrial Felts." Data include general, physical, mechanical, and chemical properties, and fabricating methods. 16 pages. Continental Felt Co., 22 W. 15th St., New York 11, N. Y.

Circle 503 on Page 19

Pressure, Vacuum Gage

Ease of calibration and adjustment of pressure, vacuum, and compound indicating gages is pointed out in Bulletin DH-54. In addition to illustrating and describing construction features and operation of movement which incorporates a helical roller, catalog describes the various types of cases, dials, and movements. 32 pages. Helicoid Gage Div., American Chain & Cable Co. Inc., 929 Connecticut Ave., Bridgeport 2, Conn.

Circle 504 on Page 19

Low-Voltage Switchgear

Design features of 600-v switchgear with K-Line circuit breakers are described in Bulletin 3200-1A. It provides comprehensive information on low-voltage power circuit breakers and switchboards, with unit ratings from 225 to 4000 amp. Advantages of the stored-energy K-Line breakers are detailed, and additional features of the switchgear are also covered. Application tables and complete selection data are given. Separate section explains short-circuit currents in low-voltage systems, using graphs, charts, and tables. 20 pages. I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa.

Circle 505 on Page 19

Process Pumps

New line of process pumps, available in 72 basic combinations, allows a choice of features for the service required. Bulletin 1-210 provides cutaway drawings of the various types, and shows how they can be combined to meet requirements. 8 pages. Byron Jackson Pumps Inc., P. O. Box 2017-A, Terminal Annex, Los Angeles 54, Calif.

Circle 506 on Page 19

Digital Totalizers

Compact design, modular, printed-circuit, plug-in subassemblies, and operation at temperatures to 160 F are features of Models 521 and 522 transistorized digital totalizers. Specification table for each model, dimension chart, and millivolt vs frequency-characteristic curves are included in Bulletin D-212-A. Transducers that can be used with the units are shown in a pictorial chart. 4 pages. Potter Aeronautical Corp., U. S. Route 22, Union, N. J.

Circle 507 on Page 19

Industrial Switches

Section of Catalog 201 is devoted to factors in applying limit switches, with emphasis on how to design actuating systems. Comparative statistics table of major switches is also included. Complete technical data on Loxswitch industrial limit switches are given, including list of forty-five contact arrangements and over 150 lever styles. 12 pages. R. B. Denison Mfg. Co., 386 Broadway, Bedford, Ohio.

Circle 508 on Page 19

Shaft Key

Double-Taper Lock Key eliminates backlash, is self aligning, and easy to install. It is described in a new bulletin which includes dimensional data and shows how the unit operates. 4 pages. Sure-Lok Co., 7701 Melita Ave., North Hollywood, Calif.

Circle 509 on Page 19

Hot-Dip Galvanized Products

Product design and assembly in relation to hot-dip galvanizing, and general factors in design and fabrication are two topics of many covered in booklet titled "Inspection Manual for Hot-Dip Galvanized Products." Other subjects include properties and corrosion resistance of galvanized steel, warpage and distortion, and ASTM specifications. 32 pages. American Hot Dip Galvanizers Association Inc., 5225 Manning Place, N. W., Washington 16, D. C.

Circle 510 on Page 19

Semiconductor Reliability

Acceptance number for any given sampling plan can be computed quickly with a new reliability nomograph. Success rate can be predicted from life test data at a 90 per cent confidence level, and sampling plan can be computed for conventional risks. Printed on sturdy card stock, nomograph contains scales and tables with complete instructions on how they work, and a glossary of terms. Semiconductor Div., Raytheon Co., 215 First Ave., Needham, Mass.

Circle 511 on Page 19

Gate, Globe, Check Valves

Illustrations with condensed descriptions and specifications on bronze, iron body, and cast-steel gate, globe, angle, and check valves, and on barstock valves and forged-steel gate valves, are contained in revised Catalog 10-B. All dimensional data for each unit are included. 16 pages. R-P&C Valve Div., American Chain & Cable Co. Inc., Reading, Pa.

Circle 512 on Page 19

Stainless Machining Chart

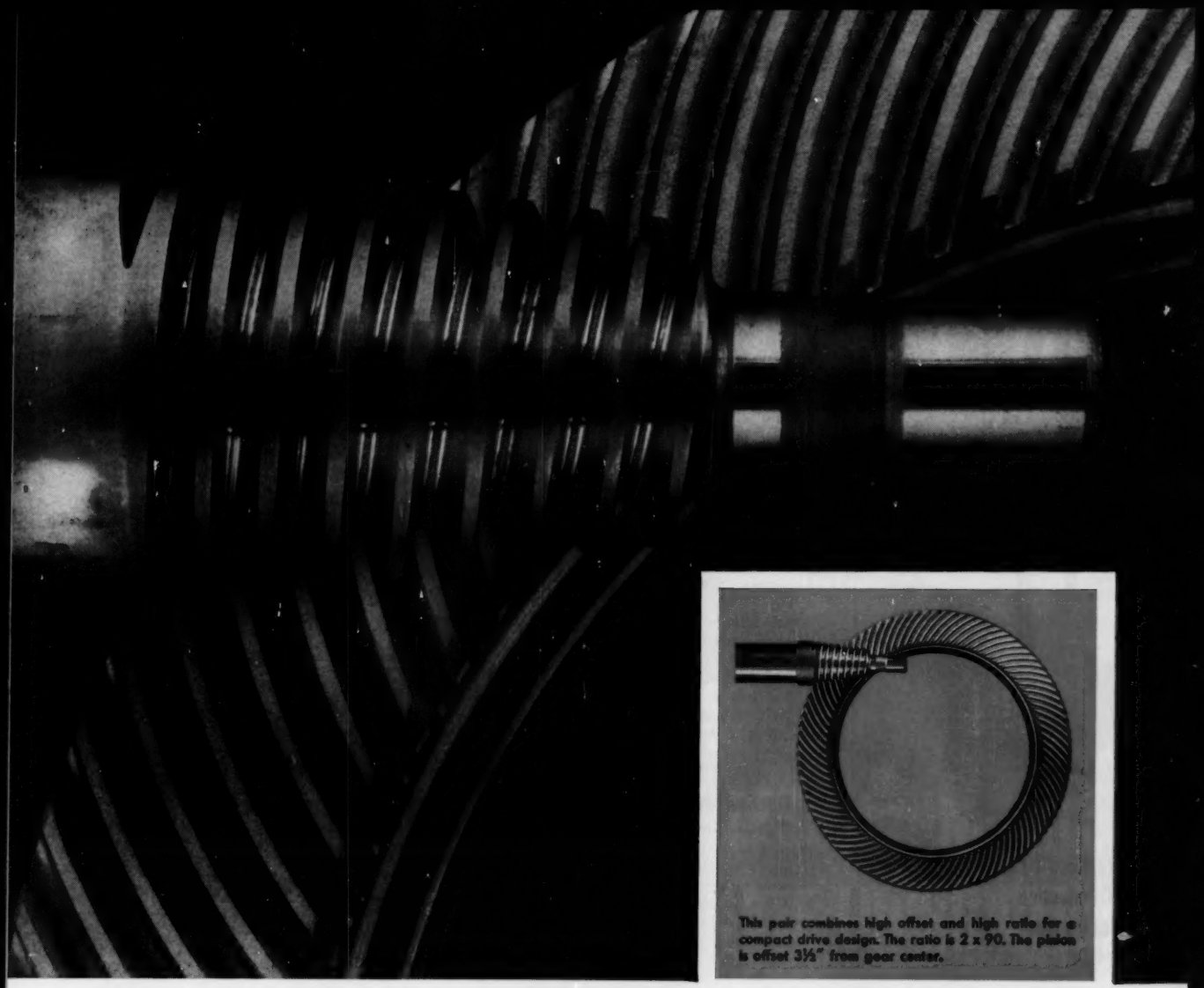
Table of recommended machining rates for 37 different types of stainless steel, including the precipitation-hardening grades, is included in Stainless Machining Chart Sec. A, No. 5. Ten separate machining operations are covered and easy-to-read conversion table is included. Printed on durable card stock, chart is 8½ x 11 in. three-hole punched and tabbed. 2 pages. Peter A. Frasse & Co. Inc., 17 Grand St., New York 13, N. Y.

Circle 513 on Page 19

Self-Sticking Tapes

New tapes for drafting, engineering, layouts, charts, and reproductions, available in a variety of sizes, can be curved easily. They are shown and described in detail in Catalog 810, "Quality Self-Sticking Tapes," which includes reproductions of all patterns and data on the kinds and sizes of tapes available for various fields. 26 pages. ACS Tapes Inc., 217 California St., Newton 58, Mass.

Circle 514 on Page 19



This pair combines high offset and high ratio for a compact drive design. The ratio is 2 x 90. The pinion is offset 3½" from gear center.

See how the teeth "wrap around" this high-reduction pinion

This is a high-ratio hypoid gear. In principle, it is not different from more conventional hypoids produced by the Gleason Works. *But . . .*

If you look closely at the pinion, you'll notice that the teeth tend to "wrap around" it. This design is extremely well suited for high reduction, strength and compact design.

The result is a conical (or sometimes cylindrical) pinion which permits *continuous tooth action—even with just one or two teeth!* Compared to corresponding bevel pinions, its diameter is greater for higher strength. An extended shank on cylindrical pinions makes *very rigid* straddle mountings practical.

You can design a *compact* unit, because high offset is possible! For high-offset *or* high-ratio pairs, the "wrap around" tooth design provides an extra measure of the smooth, quiet tooth action of hypoid gears.

High-ratio hypoids can be cut on the same Gleason equipment that is used on more familiar spiral bevel gears and hypoids. You can also use the same testers, quenching presses and other auxiliary Gleason equipment you're using now. Grinders are available for applications requiring precision finish.

High-ratio hypoids can be produced by the Gleason Works for ratios of 1:10 or 1:40 or even higher. They are finding a growing number of applications in such diverse fields as farm machinery, instrumentation and office equipment.

You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

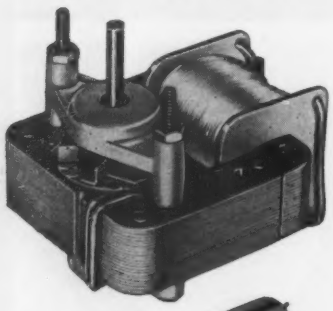
Circle 288 on Page 19

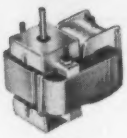
GENERAL INDUSTRIES

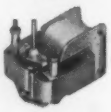
SMOOTH POWER

AC MOTORS

provide time-tested, proven dependability at lowest cost!







Standard Line AC Induction Motors from 1/1800 to 1/35 H.P.

Two and four pole, shaded pole motors backed by over 40 years of experience in producing millions of motors for large and small users throughout the world.

General Industries' modern facilities and "Know-How" make it possible to offer a combination of quality and economy unexcelled anywhere in the small motor field.

See Our Catalog in SWEETS 7a-Gen (S) or write for copy

Quantity Price Quotation On Request

THE GENERAL INDUSTRIES CO.

DEPARTMENT GK • ELYRIA, OHIO

Circle 289 on Page 19

HELPFUL LITERATURE

Differentials and Gears

Keyed drawings and tables are included for solid and hollow-shaft differentials, in wide and narrow design, in new folder containing detailed specifications and engineering information on precision differentials and end gears. Clearance circles for twelve solid-shaft differentials covered by the folder range from 1/2 to 1 13/16 in. Four tables list data on precision end gears for 96, 72, 64 and 48 diametral pitch. Each table covers 28 units and the number of teeth varies over a range from 24 to 192. 4 pages. Instru-Lec Corp., 520 Homestead Ave., Mt. Vernon, N. Y.

Circle 515 on Page 19

Solenoid-Valve Selection

Comprehensive study of solenoid-valve selection for corrosive applications includes a discussion of solenoid-valve construction and a list of over 500 corrosive chemicals commonly used in industry. Catalog Manual 108 also contains seven pages of valve-selection charts, diagrams showing normally closed and normally open configurations, a flow-versus-pressure-drop chart, and general information required to select the correct valve for a specific application. 16 pages. Valcor Engineering Corp., 365 Carnegie Ave., Kenilworth, N. J.

Circle 516 on Page 19

Decimal-Equivalent Chart

Printed in color on coated heavyweight card stock, decimal-equivalent chart provides quick conversion of Birmingham wire gages and fractions to decimals. Wire gages from 36 to 1, and fractions from 1/64 to 63/64 in. are shown in a combination color-position code to facilitate rapid identification. Chart DC-2 is 11 x 14 in., suitable for desktop or wall location. Ohio Seamless Tube Div., Copperweld Steel Co., Shelby, Ohio.

Circle 517 on Page 19

Wire Markers

Klip-Marks are slotted tubes of rigid vinyl which snap on and lift off with wires in place. Bulletin S-401 shows in pictures how the markers work, and lists two sizes which cover No. 10 to No. 20 wires. Ordering material is also included. 2 pages. Stahlin Brothers Inc., Belding, Mich.

Circle 518 on Page 19

Chemical Pumps

Information on three models of cradle-mounted chemical pumps that cover the range to 1000 gpm with heads to 240 ft is given in Form 70288. Booklet gives information on interchangeability of parts among units of various sizes, on applications, materials, operating positions, and rotation. A chart shows features of the various units as broken down to pump components, and complete dimensions are included. Horsepower range is 1/4 through 50. 8 pages. Ingersoll-Rand Co., 11 Broadway, New York 4, N. Y.

Circle 519 on Page 19

NEW!

HIGH-SPEED, SOLID-STATE, PRESET COUNTER

MACHINING AND PROCESS CONTROL
COUNTING
BATCHING
SORTING
MIXING
WINDING
PACKAGING
...or any other physical process that can be electrically digitized.

MODEL 300T

The completely transistorized Model 300T industrial counter is rugged, dependable and low-cost control instrumentation that is ideal for every use requiring a preset counting device. Modular design minimizes maintenance time and steel construction permits mounting directly on controlled machine. Modules can be easily modified for special applications. The 300T is a truly remarkable instrument that deserves your serious consideration.

Send today for complete technical information.

SPECIFICATIONS

Speed: 6,000,000 counts per minute
Range: 1 to 9,999 standard.
5 to 8 decades available
Reset: Automatic, manual, local or external
Size: 3½" high; 9½" wide; 14" deep (standard model)
Weight: Approx. 10 lbs.

ERIE INSTRUMATION

ERIE PACIFIC DIVISION • ERIE RESISTOR CORPORATION
12932 S. Weber Way, Hawthorne, California
Phone: ORegon 8-5418

Circle 290 on Page 19

Electromechanical Devices

Manual 361 assists in the selection and application of electromagnetic clutches and brakes, mechanical clutches, torque indicators, torque standards, and multi-speed transmissions. Booklet contains 16 pages of engineering and application information, a torque conversion chart, specifications, dimensional data, schematics, and general characteristics with illustrations. 60 pages. Autotronics Inc., Florissant, Mo.

Circle 520 on Page 19

Insulating Sleeving

Hygrade SR-398, Class H insulated sleeving has heat stability which permits continuous operation to 400 F. Sleeving is described in new bulletin which gives thermal, electrical, and physical characteristics of the three grades. Other silicone-rubber products are also described briefly. 4 pages. L. Frank Markel & Sons, Norristown, Pa.

Circle 521 on Page 19

Properties of Cast Irons

Significant properties and specifications of approximately 40 irons and alloys are presented in chart form for reference and comparison. "Many Irons, One Source, One Quality" covers various types of ductile iron, gray iron, ductile Ni-Resist, Meehanite, Ni-Resist, Ni-Hard, and alloyed iron. 6 pages. Hamilton Foundry Inc., 1551 Lincoln Ave., Hamilton, Ohio.

Circle 522 on Page 19

Pillow Blocks

Series P2-300 heavy-duty, ball-bearing pillow blocks are equipped with self-aligning,single-row, deep-groove, precision ball bearings. Available in a complete range of shaft sizes from ⅝ to 4 in., and conforming to basic standards of the AFBMA, they are described in Folder 2951. 4 pages. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill.

Circle 523 on Page 19

Photocathode Characteristics

On one side of a slide chart of phosphor and photocathode characteristics are the pertinent characteristics of 23 different phosphors. The other side covers 14 of the most common cathode materials. Slide chart is sturdy, pocket-sized. Component Sales, ITT Federal Laboratories, Fort Wayne, Ind.

Circle 524 on Page 19

Temperature Transducers

Having ranges with extreme limits of −435 to +1900 F, platinum resistance Weld-On temperature transducers meet the severe operating environments found in missile applications. Product Note 3010 describes the complete line of these units, giving full specifications for the various types. 4 pages. Trans-Sonics Inc., P. O. Box 328, Lexington, Mass.

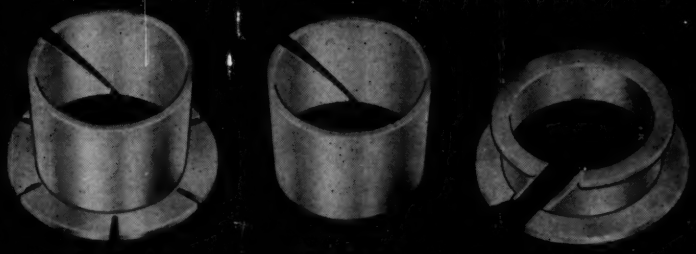
Circle 525 on Page 19

Circle 291 on Page 19→

LONG LIFE, *THOMSON* "Snap-In"

NYLINERS®

–BEARINGS of smooth, tough DuPont NYLON



Low Cost FLANGED Nyliner | Low Cost SLEEVE Nyliner | Low Cost DOUBLE-FLANGE Nyliner

COST LESS to BUY
COST LESS to INSTALL
& ELIMINATE LUBRICATION

Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
- LESS SERVICING
- SELF-RETAINING
- RESIST CORROSION
- LOW FRICTION
- RESIST POUNDOUT
- NO FRICTION OXIDATION
- DAMP VIBRATION
- OPERATE IN LIQUIDS
- NON-CONTAMINATING
- INSTANTLY REPLACEABLE
- RESIST ABRASION
- MINIMUM SPACE
- SILENT OPERATION
- LIGHTEST WEIGHT
- REDUCED WEAR

Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

THOMSON INDUSTRIES, Inc.

DEPT. 4, MANHASSET, NEW YORK

Also— —Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting

Versatility

IN STAINLESS STEEL

... from highly accurate air-operated sanitary valves to unbelievably deep draws to specialty products, A-P-C versatility in drawing, welding and fabricating sets the pace for the stainless steel industry. Engineering know-how, manufacturing craftsmanship, increased production capacity provides you with components and parts far better and faster than ever.

A-P-C welcomes your investigation as the answer to all stainless steel requirements. Just a postcard brings a prompt reply.

ALLOY PRODUCTS CORP.

1067 PERKINS AVENUE • WAUKESHA, WISCONSIN

Circle 293 on Page 19

HUMAN-FACTORS ENGINEERING

by John D. Vandenberg and C. Thomas Goldsmith

Thirty-one pages of helpful information for the designer contending with human limitations and capabilities. Special emphasis is given to design for vision, hearing, muscular performance and body dimensions in relationship to man-machine efficiency $1.00 per copy

A MACHINE DESIGN REPRINT

ORDER FROM: Machine Design Reader Service

Penton Building, Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order)

Selsyn Indicating Systems

Bulletin GEA-7218 gives data for remote indication and remote control. It details some of the many possible applications of the selsyn monitoring system, and lists several indicator arrangements available. Use of cam-operated limit switch as an automatic feedback control is covered. Brochure contains specification tables to select dial type, degree of accuracy desired, appropriate indicators, and transmitters. 6 pages. General Electric Co., Schenectady 5, N. Y.

Circle 526 on Page 19

Fractional-Horsepower Motors

Bulletin PL-SB2820 on fractional-horsepower motors lists all standard units normally carried in stock and available for short delivery. Publication covers over 500 different general and special-purpose motors including jet-pump motors, oil-burner motors, belt-drive furnace-blower motors, air-circulating motors, and sump-pump types. 4 pages. Industrial Motor Dept., Westinghouse Electric Corp., Lima, Ohio.

Circle 527 on Page 19

Vibration Inducers

Various types of rotary vibrators and electrical vibration inducers are covered in Form 1044. Units are pictured and shown in several applications, and complete specifications are included. A group of mounting auxiliaries is also shown. 6 pages. Martin Engineering Co., Neponset, Ill.

Circle 528 on Page 19

Agitation-Equipment Drive

Bulletin 1001 describes features of TW drive which provides quiet agitation in open or closed chemical vessels. Photographs are used to show how compact design provides maximum free area for vessel piping and top head accessories, and cut-away drawings show how seal or stuffing box has been made integral with drive support to eliminate variation between components. Second half of the bulletin is devoted to individual description and specifications for each primary type of TW drive. Dimensional drawings, weights, agitator speeds, and horsepower ratings are provided. 8 pages. Pfaudler Co., 1127 West Ave., Rochester 11, N. Y.

Circle 529 on Page 19

Diaphragm Valves

Data on eight types of air operators for diaphragm valves are given in Bulletin 134-A. Operators available from stock are listed for valves from ½ through 12-in. sizes. Sectional drawings, descriptive information, tables of air actuator pressures for various line pressures, dimensional data, and ordering instructions are provided for air open-spring close, spring open-air close, and air open-air close types of operators. 6 pages. Hills-McCanna Co., 400 Maple Ave., Carpentersville, Ill.

Circle 530 on Page 19

Transistor Heat Dissipators

Transistor heat dissipators available for a variety of sizes and types of power diodes and transistors are discussed in a new bulletin. Three basic package sizes with various configurations for suitable mounting of JEDEC case sizes used in transistors and diodes are shown. 4 pages. U. S. Heat Sink, 637 S. Isis Ave., Inglewood, Calif.

Circle 531 on Page 19

Temperature Recording

"Temperature Recording from Platinum Resistance Sensors" describes and illustrates how a Universal carrier amplifier and a platinum resistance sensor are applied to provide a combination for recording temperatures from −320 to +2000 F with temperature deviations of 1/100 of 1 deg. Basic setup procedures, temperature compensation, bridge circuits, calibration charts, and recording accuracy are also described in Booklet Form TR. 12 pages. Brush Instruments Div., Clevite Corp., 37th & Perkins, Cleveland 14, Ohio.

Circle 532 on Page 19

Indicators, Controllers

Thermo Electronic indicators and indicating controllers provide rapid automatic indication and/or control of a variety of industrial processes. Bulletin 67 explains operating principles, two or three-position control features, applications, small space installation, and special design features of potentiometer or bridge models. Further information on conservatively rated components is given, and specifications on the sensitivity, accuracy, response speed, operating requirements are also provided. 4 pages. Thermo Electric Co. Inc., Saddle Brook, N. J.

Circle 533 on Page 19

Lightweight Fittings

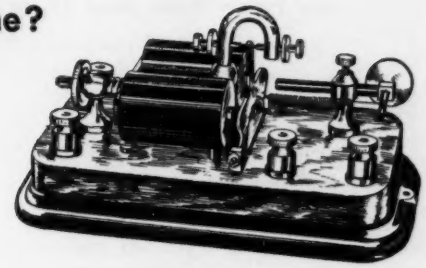
Engineering details relating to a new series of lightweight fittings for missile plumbing are included in new brochure. Contained within the brochure are diagrams and charts explaining the general environmental and use requirements, test data on the performance of individual components, and availability of the various sizes and materials to fulfill a variety of desired applications. 8 pages. Harrison Mfg. Co., 2908 N. Naomi St., Burbank, Calif.

Circle 534 on Page 19

Commercial Glass Properties

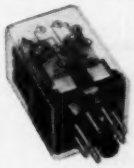
Expanded data on corrosion resistance and thermal expansion of 32 commercial glasses are additions to revised Booklet B-83, "Properties of Selected Commercial Glasses." Pamphlet also contains more complete information on evaluating the hardness of glass, and includes standard sections on mechanical, electrical, and optical properties, thermal stress, heat transmission, and viscosity of the glasses. 16 pages. Write on company letterhead to Corning Glass Works, Corning, N. Y.

where have the simple relays gone?



Many, of course, have disappeared along with the relatively simple jobs they were asked to perform. (A good telegraph relay* or pulse repeater today, for example, should not only be small but able to transfer its contacts on a milliwatt or so about 500 times a second for half a billion operations — and then be repairable, adjustable and lovable besides.) But there are still plenty of naive, uncomplicated loads around that ask only to be switched on and off, at reasonable intervals, by a device that doesn't have so many parts and fancy thingamajigs that it may become temperamental and refuse to work without being coaxed.

For such applications we are happy to say we have a paragon of ingeniously simple, fool-proof relay design. It won't make the same confidence-inspiring noise as the classic above and it's not for telegraphy, but you can see through its enclosure and watch its contacts surely open and close. The designer *started* with the familiar enclosure and octal plug-in base and then developed the relay accordingly (with UL requirements in mind); he didn't just take an existing relay and tack on a new base and enclosure. As a result, the parts make the best use of the volume (1 5/16" square x 2 1/16" high) and are big, simple, rugged and few in number. The base is specifically designed to carry the 10 amp. loads the relay will switch.



Plug (octal, that is) for Sigma Series 72 relay

The relay is designated "Series 46" and intended for general purpose, heavy-duty DPDT switching on AC or DC inputs. Rated DC loads are 5 amps at 28 volts, 1 amp. at 120 volts; AC, 1200 volt-amperes per pole with 240-volt and 10-amp. maximums. Life ranges from 10 million operations with 1-amp. loads to half a million with 10-amp. loads. The relay can be as sensitive as 200 milliwatts DC, or 0.2 v-a AC.

We've looked at what else is available for the same modest price and the "46" specs give us considerable hope. If your problem has been the right specs but the wrong price, or vice-versa, perhaps you'd like the 46 AC and DC bulletins. In the meantime, always remember: You can be sure if it's Sigma, it's simple.

SIGMA

SIGMA INSTRUMENTS, INC.
89 PEARL ST., SO. BRAINTREE 85, MASS.

Circle 294 on Page 19

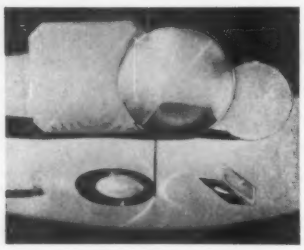
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Optical Lenses

of flat plastic give high performance

Frenelenses are thin, light, flat sheets of transparent grooved plastic. Each groove is a minute refracting facet of a circular prism, forming many microscopic optical elements capable of bending light in a variety of ways. There can be several hundred to several thousand such prisms on the surface, depending on the requirement. Since the lens is the reproduction of a curved



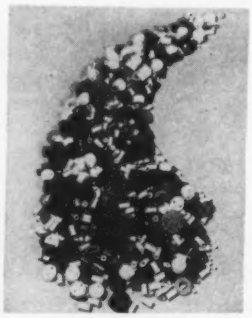
surface as a plane, it is possible to correct for spherical aberration inherent in regular lenses. Thickness of the unbreakable lenses varies from 10 to 100 mils. They can be cut, turned, drilled, sawed, machined, and cemented to a support. **Stocker & Yale Inc.**, 366 Green St., Marblehead, Mass.

Circle 535 on Page 19

Epoxy Pellets

can be made in any shape

Epoxy bonding material in easy-to-handle pellets eliminates difficulty in mixing, difficulty in metering, and skin irritation. Pellets will bond practically any kind of material to any other kind. Shear strength of a steel-to-steel bond is 4700 psi, and softer materials tear before the bond fails. Pellets also have good chemical and solvent resistance, low moisture permeability, and good electrical characteristics. By modifying



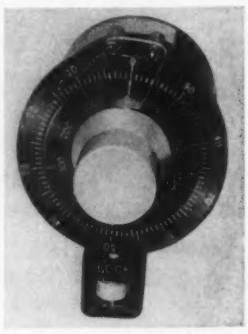
pellet composition, bonding material can be made either flexible or rigid. Pellet size is tailored to each bonding application so that when the pellet melts it provides exactly the right amount of adhesive for the job. Curing temperature can be varied from 85 C for bonding heat-sensitive components to 250 C for a fast-cure bond. Pellets can be made in any desired shape. **Epoxy Products Inc., Div., Joseph Waldman & Sons**, 137 Coit St., Irvington, N. J.

Circle 536 on Page 19

Dual-Speed Drive

provides positional accuracy of 12 min of arc

Miniature dual-speed drive, designated DSD-40, meets the need for a low-cost, miniature precision gear reducer and provides a positional accuracy of 12 min of arc. Drive provides precise and repeatable po-



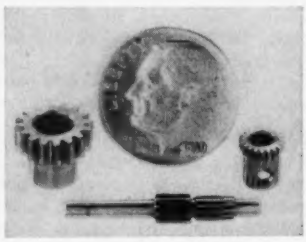
sitioning of rotary components such as potentiometers, resolvers, and syncros. Knurled thumbwheel actuates a Delrin screw and axially locks the outer dial securely on exact setting. Drive meets environmental specification MIL-E-4970 (USAF). **Mechanical Products Div., Technology Instrument Corp. of Acton**, 533 Main St., Acton, Mass.

Circle 537 on Page 19

Pinions, Precision Gears

in more than 1000 sizes and varieties

Line of pinions is offered in any number of teeth from 10 to 35, and any length from ½ to 2 in. Complete line of spur gears is also carried, as well as 50,000 gear blanks.



Hiram Jones Electronics, 1010 Oak St., Burbank, Calif.

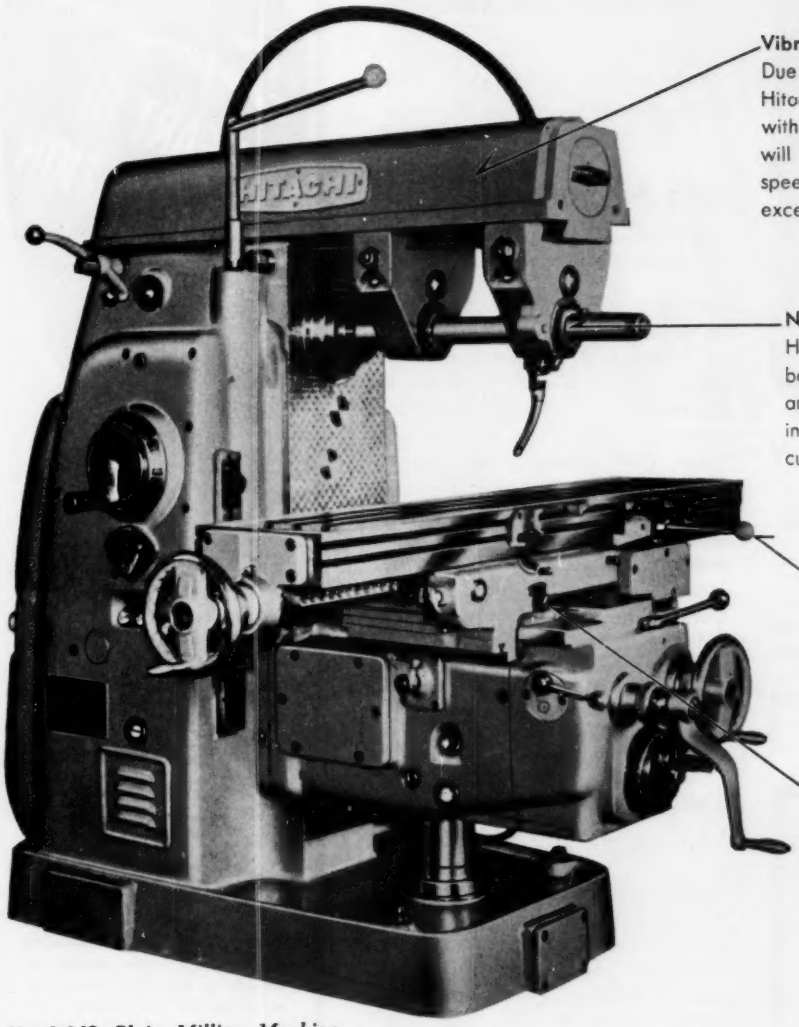
Circle 538 on Page 19

Miniature Check Valve

handles pressures to 20,000 psig

Miniature, stainless-steel check valve, Model CV17, can be used in applications with corrosive fluids or hot exhaust gases to 1800 F, and handles pressures to 20,000 psig. Fast-acting metal poppets or plastic-coated poppets are available. Ports shown are per MS33656-4 for connection with ¼-in. tubing or hose. Over-all length, including

HITACHI
NO. 2 ML MILLING MACHINES



No. 2 ML Plain Milling Machine

Vibration Damping Device
Due to a vibration damping device of Hitachi's exclusive design contained within the over-arm, minimum vibration will be set up even during higher speeds and feeds operation, so that an excellent finished surface is obtained.

New-Type Arbor Support Bearing
Hitachi's unique super precision-type bearing, a combination of plain metal and needle bearing, is incorporated into the machine to enable high speed cutting with high precision results.

Mono-Lever Control System
Hitachi's unique Mono-lever Control System makes the operation simple and easy. Table-feeding too can be performed with ease.

Backlash Eliminator of Lead Screw
As the use of two independent nuts eliminates backlash on the table feed screw, smooth down-cutting can be effected.

SPECIFICATIONS :

- 53 1/8"×10 1/16" Table
- 28" Longitudinal Traverse
- 16 Table Feeds 1/16" — 78 3/4"/min.
- 16 Spindle Speeds 25 — 1,500 r.p.m.
- 7.5 h.p. Main Motor

Hitachi, Ltd.
Tokyo Japan

Cable Address : "HITACHY" TOKYO

5 STEPS ELIMINATED

by BRIDGEPORT'S new Cored Forging Method

Originally, this one piece brass forging was a casting-plus-brazed-rod assembly. Now it is struck from a single billet. Tapping alone replaces 6 previous production steps.

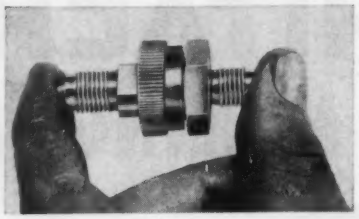
Checked below are the Bridgeport Cored Forging benefits applying to the power switch part shown above.

	closer tolerances
✓	denser, stronger grain
✓	less machining to finish
✓	no assembly required
	thinner walls or sections
	less finished weight
	multiple coring
✓	less scrap/rejects
✓	lower cost plating

Which of these process savings or product improvements would apply to *your* part or assembly? Write for descriptive brochure...or send your parts or drawings for our evaluation...to:

CORED FORGINGS DIVISION
BRIDGEPORT BRASS COMPANY
1000 Connecticut Ave., South Norwalk, Conn.

Circle 296 on Page 19



fittings, is 2⅛ x 1 in. diam, and weight is 0.125 lb. **Marotta Valve Corp.**, Boonton, N. J.

Circle 539 on Page 19

Spray Adhesive

speeds assembly of lightweight materials

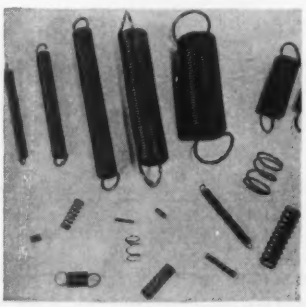
Spraygrip is a low-pressure, spray-on adhesive, sprayable at pressures of 5 psi. It provides excellent adhesion of metal and plastic panels to insulating materials such as felt, asphalt-impregnated paper, glass fiber, polyethylene, and polyurethane sponge and foam. The one-surface adhesive is sprayed on for immediate assembly. It is completely resistant to moisture and to extremes of temperature, remains flexible and cannot crystallize, providing continuous protection against vibration. **Anchor Adhesives Corp.**, 36-23 164th St., Flushing 54, N. Y.

Circle 540 on Page 19

Coil Springs

in over 800 new sizes

SPEC precision compression and extension coil springs available as stock items have been increased to more than 1500 sizes with the addition of 800 new sizes. Compression springs range in OD from 0.057 through 0.720 in. to fit standard holes, with wire diameters of 0.006 through 0.072 in. Extension spring



MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL
1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J
ARmory 4-8989

Circle 297 on Page 19

diameters range from 0.063 through 1.0 in. and lengths range to 5 in. Units are available in music wire for standard applications or in stainless steel for applications where temperatures range to 250-500 F. Both types of wire are certified to military and aircraft standards. **Associated Spring Corp.**, Bristol, Conn.

Circle 541 on Page 19

Speed Reducer

transmits 0.95 hp at output speed of 85 rpm

Torque-Arm fractional-horsepower speed reducer, identified as TD025, has a gear ratio of 25:1 and transmits up to 0.95 hp at maximum recommended output speed of 85

rpm. A predetermined combination of reducer and V-belt drive provide any speed ratio of 175:1. As a shaft-mounted reducer, unit is equipped with a torque arm for simple adjustment of V-belt drive center distance. Overload release is optional. As a flange-mounted reducer, it can be bolted directly to the driven machine or supporting structure. Unit is bored for mounting on 1¼ in. shafts, and bushings can be furnished to adapt for smaller shafts. **Dodge Mfg. Corp.**, Mishawaka, Ind.

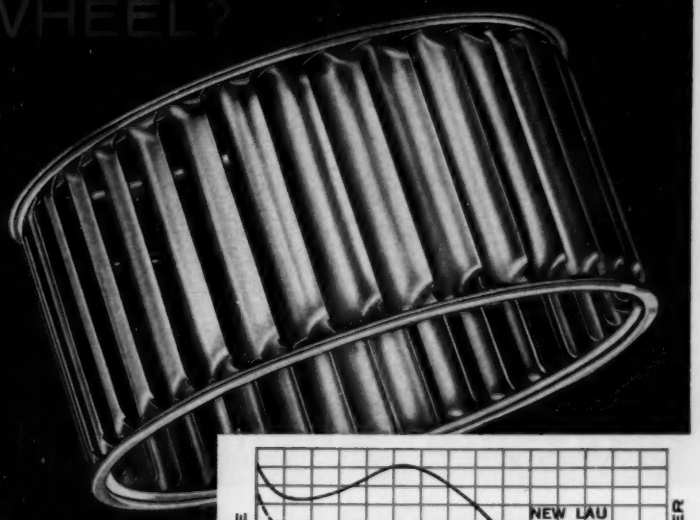
Circle 542 on Page 19

Synchronous Motor

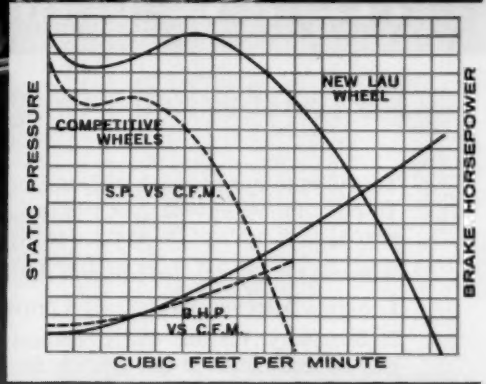
is two-pole unit of open-end ventilated type

M49-frame reluctance synchronous 3-in. diam motor is a two-pole unit of open end-ventilated construction. Improvements in electrical performance include use of Class B

DO YOU NEED A HIGHER EFFICIENCY SMALL BLOWER WHEEL?



GET INCREASED PERFORMANCE WITH THE NEW LAU 4¾ to 8½ SPUN WHEEL



Lau Engineering has successfully developed a blower wheel that out-performs any wheel of comparable size tested. This powerful, compact unit is specifically designed for installation in room air conditioners but can be used effectively in most appliance applications. Lau "spun" construction contributes greatly to the wheel's structural rigidity and to a very high CFM to WATT ratio.

This new Lau wheel is offered in a customer's choice of aluminum, cold rolled steel or zinc grip and in a range of diameters, blade lengths, bore sizes and back plate designs.

LAU THE LAU BLOWER COMPANY
2027 Home Avenue Dayton 7, Ohio

Get this free engineering data file on the new Lau high performance appliance wheel.

Mr. Wm. H. Wentling, Director of Engineering
The Lau Blower Co., 2027 Home Ave., Dayton 7, Ohio

Please send me your engineering data file on the new Lau high performing wheel. ☐ We would like to see sample wheel.

Name_____

Position_____

Company Name_____

Address_____

Circle 298 on Page 19

the secret of Ford's swing-away wheel

The secret of the new swing-away steering wheel in the Ford Thunderbird is a flexible shaft between the stub shaft in the steering gear box and the upper steering rod.

Here are the benefits derived from flexible shafts:

1. *Safety.* Safety against failures is provided.

2. *Durability.* Flexible shafts eliminate the possibility of play or lost motion at this juncture for the life of the car.

3. *Compact.* The flexible shaft is more compact than conventional joints.

4. *Strength.* In case of power steering failure, the maximum torque would be 660 pound-inches, which would occur during parking on dry pavement. The flexible shaft can absorb this and *much more.*

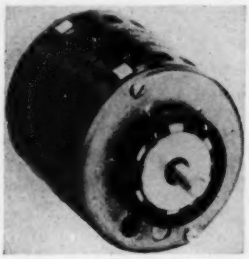
Here is another example of creative engineering with flexible shafts. Investigate for yourself how they can solve many of your design problems and at the same time reduce costs.

S. S. WHITE INDUSTRIAL DIVISION,
DEPT. 4 10 East 40th Street, N. Y. 17, N. Y.

THE S. S. WHITE FLEXIBLE SHAFT HANDBOOK
New 4th Edition... Send for your free copy!

1164

S.S.White
FIRST NAME
IN FLEXIBLE SHAFTS



material for stator core insulation to ground, and an epoxy blue-gray varnish treatment for windings and shell finish. Varnish treatment acts as an insulation, a bonding agent, and a protective, moisture-resistant coating. Line covers continuous-duty ratings from 15 to 35 mhp in synchronous, and through 1/12 hp in split-phase, two-pole designs. **General Electric Co.**, Schenectady 5, N. Y.

Circle 543 on Page 19

Thin Switch

has only one stressed metal part

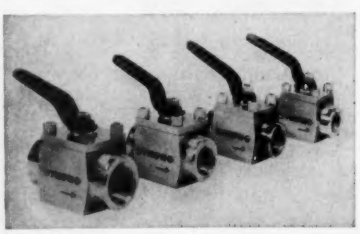
Thin M switch can be stacked four to the inch. Model has only one stressed metal part, Faston or solder terminals, integral and detachable leaf and roller actuators, and operating forces starting at 20 grams. It is available in 3 and 6-amp units. **Acro Div., Robertshaw-Fulton Controls Co.**, Columbus, Ohio.

Circle 544 on Page 19

Top-Entry Ball Valves

have one-piece body design

Evrtyte ball valves provide on-off valving of gas, air, oil, water, or liquid chemicals. One-piece body is cadmium-plated carbon steel or stainless-steel bar stock. Threaded inlet and outlet connectors permit fast, positive installation in 3/8, 1/2, 3/4, and 1-in. lines. Large arrow indicating the flow direction is cast



Circle 299 on Page 19

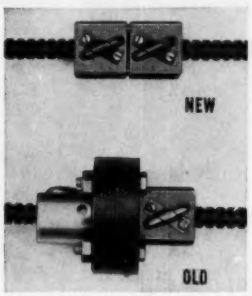
into the valve body. Maximum pressure-temperature ratings are 150 psi at 365 F for steam lines, and 1000 psi for water, oil, liquid, chemical and gas-handling applications. New valves provide a fuller flow than previously obtainable in ball valves designed for the same pipe sizes. **Strong,** 508 Sandusky St., Conneaut, Ohio.

Circle 545 on Page 19

Screw Assembly

incorporates spring-pin preloading

Backlash of ball-bearing screw assemblies, normally eliminated by providing mating flanges on two ball nuts for each assembly, has now been eliminated by a recently developed method of spring pre-



loading which lowers space requirements and cost of the assembly. In this design, two torque pins backed by springs provide rotational restraint between the ball nuts, while applying a preload determined by the capacity of the springs selected. **Saginaw Steering Gear Div., General Motors Corp.,** Saginaw, Mich.

Circle 546 on Page 19

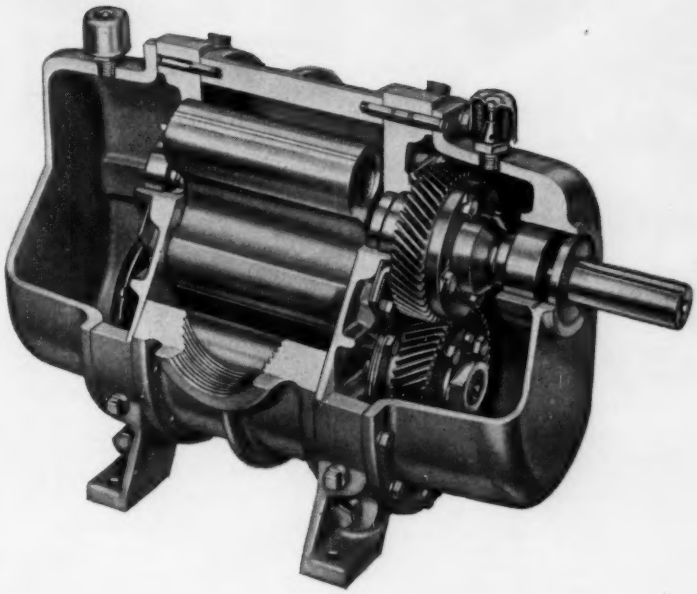
Vibration-Damping Devices

reduce resonant amplitudes of vibrating structures

Strip-Dampers minimize vibration response of such structures as airframe components, electronic chassis, air ducts, and shock and vibration test fixtures. Units dissipate the mechanical energy of vibration through viscoelectric shear damping. Weighing less than 1½ oz, including attaching clips, Strip-Dampers are 11¾ in. long but can be cut easily to shorter lengths for small-area applications, with little loss

NEW

m-d Standard Duty Blowers-Series 16



Engineered specifically for pneumatic conveying applications

The new Standard Duty M-D Rotary Positive Blower Series 16 combines all of the ruggedness and dependability of ductile iron with the flexibility, lighter weight and lower cost of aluminum blowers.

Eleven models ranging from 50 CFM of air with pressures up to 12 PSIG or up to 12" HG vacuum have been specifically designed for material handling system applications.

Send us your air or vacuum requirements. We'll be glad to make recommendations.

For full information, write

M-D BLOWERS, INC.

Racine, Wisconsin

A SUBSIDIARY OF MIEHLE-GOSS-DEXTER, INC.

Circle 300 on Page 19

There's an O-M Cylinder for Every Purpose

MEET JIC STANDARDS

With the introduction of the new O-M Series "K," Square Head Air Cylinder, we can now supply the right air or hydraulic cylinders for your specific applications on low or high pressure systems. Ruggedly constructed of the highest quality materials, accurately machined to close assembly tolerances, O-M Cylinders operate with high efficiency and are quickly and easily maintained.

Whether your spec's call for a cylinder for a single operation or a variety of cylinders for a sequence of operations under continuous automatic cycling, there is an O-M Cylinder to meet your requirements. O-M Cylinders are individually tested at the factory and are available with standard or oversized rods, completely interchangeable parts and mounts.

Mail coupon TODAY for latest Bulletins showing construction and dimensional details, engineering drawings, capacity chart and mounting data.

Improved Tie-Rod Type Series 105A (Heavy Duty), Hydraulic 2000 psi; 3000 psi non-shock not illustrated. Bulletin 105A

Automation Type 200 psi Air Series RA, 1000 psi Hydraulic Series RH not illustrated. Bulletins 107-108

ORTMAN-MILLER MACHINE CO.
7143rd Street, Hammond, Ind

Send Bulletins ☐ Have representative call.

☐ 101A ☐ 105A ☐ 107 ☐ 108 ☐ 115

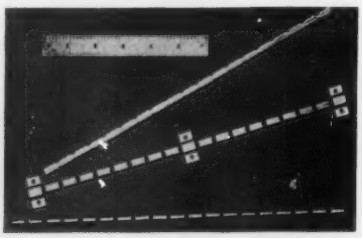
Name_____ Position_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 301 on Page 19



of damping efficiency. Attaching hardware consists of special clips designed to be riveted or bolted in place, or dampers can be attached with epoxy glues. Units can be used under operational temperatures from −80 to +350 F. They resist moisture, fungus, oils, and solvents, weathering, ozone, aging, and material fatigue. **Barry Controls Div., Barry Wright Corp.,** 700 Pleasant St., Watertown 72, Mass.

Circle 547 on Page 19

Printed-Circuit Laminate

has high tensile and impact strength

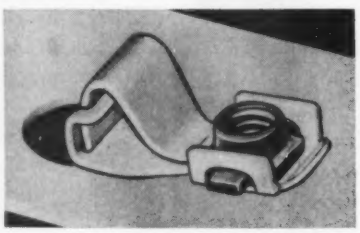
Cimclad copper-clad laminate provides high tensile, flexural, and impact strength of glass-fiber-reinforced plastic. In addition to eliminating printed-circuit-board breakage, the glass reinforcement and resin system provides high electricals, including low-loss factors, increased insulation resistance, and low moisture absorption. Material is easy to process, cold punches well at room temperatures, and is self-extinguishing. **Cimastra Div., Cincinnati Milling Machine Co.,** Cincinnati 9, Ohio.

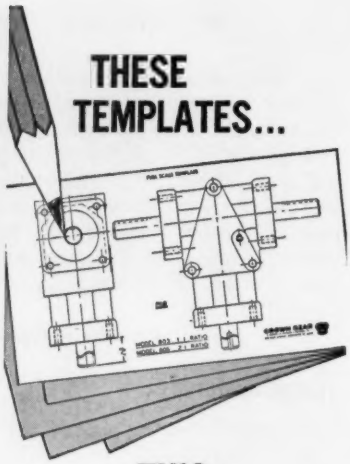
Circle 548 on Page 19

Clip Nut

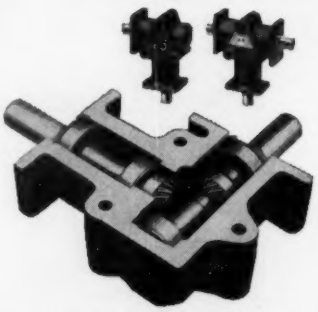
in No. 8-32 and 10-32 sizes

SL100 clip nut features a strong spring clip and "wrap-around" retainer design through which spring and retainer work together to re-





THIS CROWN "PACKAGE"



wrap up your right-angle design problem!

. . . And the transition to the "Package" concept of right-angle power transfer is that simple with this easy-reference template kit. 18 basic Crown right-angle units are shown on six template sheets, each full scale.

WHY spend countless hours on research and drawings? **WHY** purchase expensive patterns, core boxes, castings, steel and other materials? **WHY** manufacture fixtures and gages? **WHY** machine, inspect, assemble and test components?

WHY NOT OBTAIN THE IDEAL SOLUTION TO YOUR RIGHT-ANGLE PROBLEM . . . IMMEDIATELY, AND AT TREMENDOUS SAVINGS?

Your local Crown Gear Distributor (Listed in Power Transmission Design Directory) has the answers . . . and your Template Kit. Call him or consult factory.

CROWN GEAR

320 PARK AVE., WORCESTER 10, MASS.
A Division of Harrington & Richardson, Inc.

Circle 302 on Page 19

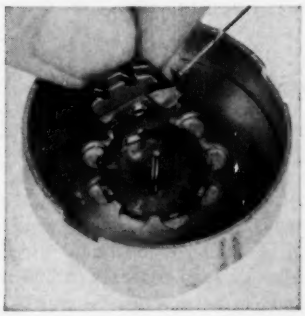
sist torque-out and push-out. Sizes now offered include No. 8-32 and No. 10-32, for mounting on panels to 0.090-in. thick and with edge margin to ½ in. Thread-locking to MIL-N-25027 is standard. **Shur-Lok Corp.**, 879 S. East St., Anaheim, Calif.

Circle 549 on Page 19

Synchronous Motor

has L-shaped, variable-pole arm

VP-III high-torque, permanent-magnet synchronous motor for program timers, computers, displays, and other electromechanical devices uses an L-shaped, variable-pole arm to make it impossible for



the motor to fail to start because of being on dead center. If the poles of the rotor should stop on dead center, magnetism induced in the variable-pole arm by the field coil will start the rotor into motion, giving both permanent and alternating polarity to the rotor. Standard motor speeds available range from 10 to 1/60 rpm. Motor is available in clockwise or counterclockwise rotation, 115 v, 60 cycles standard. Standard motor is rated at 20 oz-in. at 1 rpm and the high torque model is rated at 40 oz-in. at 1 rpm. **Lake City Inc.**, Crystal Lake, Ill.

Circle 550 on Page 19

Shaft Collar

transmits torque and/or thrust loads without keyways

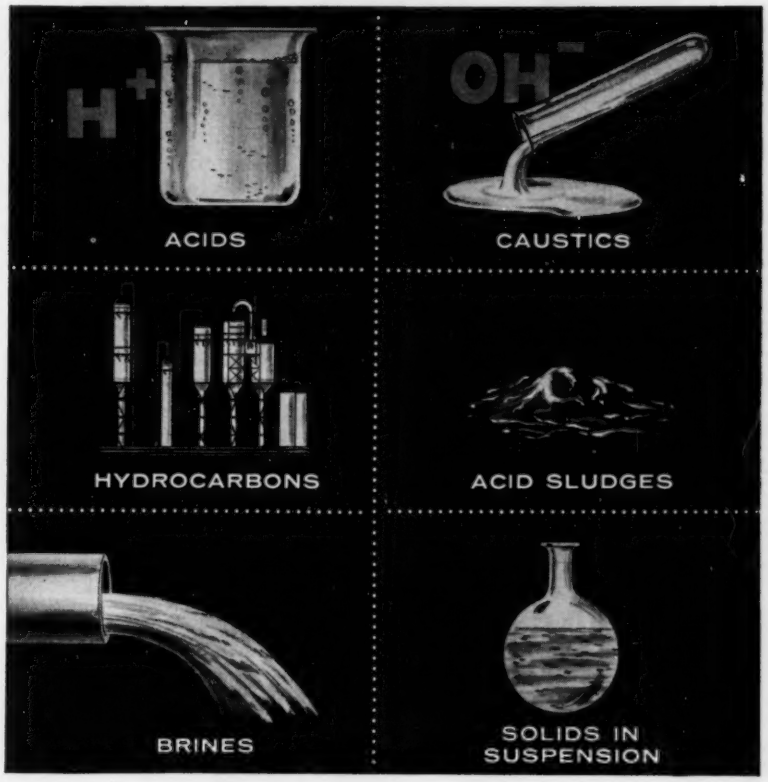
New torque collar combines threaded mounting flange and an independent-acting, spring-locking shaft collar into a one-piece unit. Locking action, achieved without a

AMPCO®

Do you have to

COPE WITH THESE CONDITIONS

to keep on stream?



you combat them all with an

AMPCO® metal

What can a copper-base alloy do for you? Whatever it is, there's a specific AMPCO metal — or other Ampco alloy — that does the job exactly.

Equally important, you can select the best, most economical form of production — fabrication, sheet, plate, tubing, pipe and fittings, extrusion, forging, sand casting, centrifugal casting.

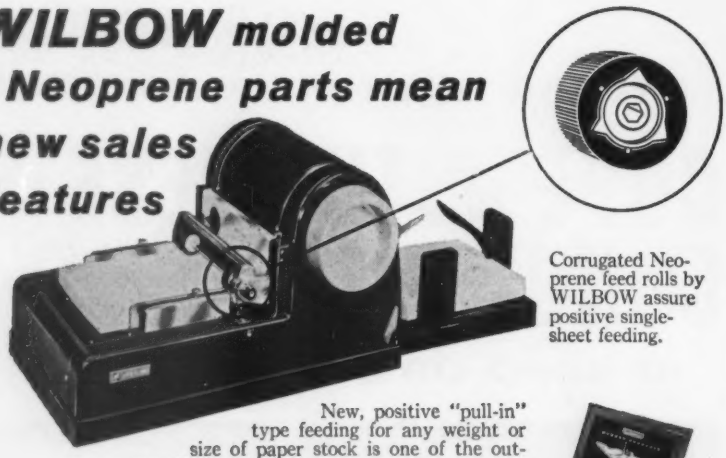
Call in your Ampco field engineer.

G-22

AMPCO METAL, INC., Dept. 30G, Milwaukee 1, Wis.
WEST COAST DIV.: HUNTINGTON PARK, CALIFORNIA • SOUTHWEST DIV.: GARLAND (DALLAS COUNTY), TEXAS

Circle 303 on Page 19

WILBOW molded Neoprene parts mean new sales features



Corrugated Neoprene feed rolls by WILBOW assure positive single-sheet feeding.

New, positive "pull-in" type feeding for any weight or size of paper stock is one of the outstanding performance features of the recently introduced *Liberator 600* Duplicator by Speed-O-Print Corporation. To produce the specially engineered feed rolls required, with precisely controlled characteristics of size, yield, texture and wear resistance, Speed-O-Print called on WILBOW.

WILBOW excels in the manufacture of high-performance, high-precision mechanical rubber parts to meet the most exacting requirements. A full range of synthetic, natural or silicone polymers . . . plus complete equipment for molding, lathe cutting, die-cutting or extruding . . . is at your service to make the parts that will give your product new sales appeal. Why not check the possibilities with WILBOW today?

SEND FOR COMPLETE WILBOW CATALOG

wilbow

The WILLIAMS-BOWMAN RUBBER CO.

1951 South 54th Avenue • Cicero 50, Illinois • (Chicago Suburb)

Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

Circle 305 on Page 19

Design Guide to

Adjustable-Speed Drives

- **ELECTRICAL**
- **MECHANICAL**
- **HYDRAULIC**

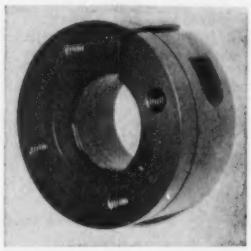
$2.00 per copy

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

(Remittance or Company Purchase Order must be enclosed with order.)

MACHINE DESIGN READER SERVICE

Penton Building
Cleveland 13, Ohio



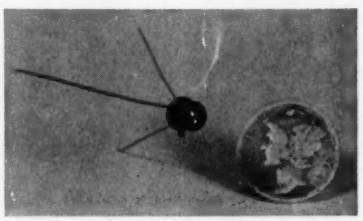
threaded fastener, is equivalent to a shrink fit. Unit transmits torque and/or thrust loads without keys, keyways, setscrews, or other auxiliary devices. It permits precise timing on automatic machinery, and will not score the shaft; overload slip feature protects machine parts in case of a jam. Collar is available in sizes from ½ to 2-in. bores. **Kolock Products Co.**, P. O. Box 200, Lutherville, Md.

Circle 551 on Page 19

Semiconductor Photocell

has light-trigger level of 80 ft-c

Photran bistable PNPN light-actuated silicon switch, packaged in JEDEC TO-18 outline, directly handles dc load currents to 300 ma. Output is determined primarily by the load, and is independent of light input at all intensities above the triggering level. Typical light-trigger levels have now been re-



duced to the area of 80 ft-c. **Solid State Products Inc.**, One Pingree St., Salem, Mass.

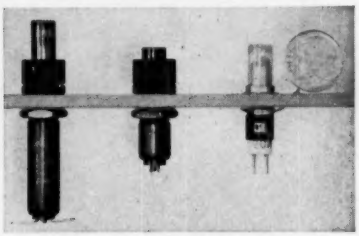
Circle 552 on Page 19

Miniature Indicator Lights

consist of lamp cartridge and mating lampholder

Mini-Cator miniature indicator lights are intended for use on electronic equipment, computers, display panels, precision machinery, and military electronic equipment. They consist of a replaceable lamp

cartridge and mating lamp holder. Lampholder mounts in a 3/8 in. diam hole and features a black-anodized aluminum case, nylon insulation, and solder lugs which can be used as common terminal for several wires. Cartridges feature a tough nylon shell and stainless-steel pins, and can be used with the lampholder or mounted directly in a 9/32-in. diam hole with a spring-steel clip. They incorporate either neon or incandescent lamps for a wide range of voltages, and can be supplied with imprinted lenses in a



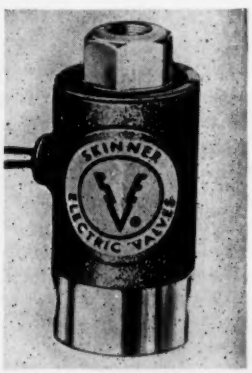
variety of colors. **Industrial Devices Inc.**, Edgewater, N. J.

Circle 553 on Page 19

Solenoid Valves

have diam of 1 in.
and weigh 5 oz

B Series subminiature solenoid valves are designed for use in hydraulic and pneumatic devices and control systems, and operate with all common media including many semicorrosive fluids. Body and operating parts are stainless steel. Valves are 1 in. in diam by 2 1/4 in. high and weigh 5 oz. Orifices are 3/16 in., and fluid connections are all 1/16 in. PTF. Because of the small size, fittings are provided with each valve to adapt to standard 1/8-in. flared tube. Operating differen-



For overcurrent protection that fits hand-in-glove with tight operating specs, try the Heinemann Type C Overload Relay. You can practically design it yourself, to your particular requirements. And at reasonable cost. You not only can specify the exact integral or fractional continuous-duty current rating you need (between 0.02 and 60 amps), you can spec response characteristics, too. Within broad overall limits, you can have the precise time-delay-vs-overload action you want. All you have to tell us is the time within which actuation must occur at any specified overload value. In most cases, this value can be as low as 115% rated load. (Because the Type C is magnetically actuated, the calibrated trip points you select will remain constant for the life of the relay—no ambient-temperature compensation is necessary.) ■ Optionally available with trip indication and lock-out features, the Type C Relay is fully described in our Bulletin 5103. Write for a copy.

HEINEMANN ELECTRIC COMPANY, 172 BRUNSWICK PIKE, TRENTON 2, N. J.

SA 2389

Circle 306 on Page 19

... another NEW product from Stearns

... pace-setting pioneer in electro-magnetic clutches—brakes—clutch-brakes

NOW AVAILABLE—
540 lb-in. Torque Miniature Clutch
Model 5.5
Style SMR*
(Shown ½ Size)

*Style SMR signifies Stationary Magnet Body, Rotor—Ball bearing mounted.

MORE TORQUE PER POUND . . .
MORE TORQUE PER CUBIC INCH . . .
weighs 24%—63% LESS, occupies 19%—64% LESS cubic area,
than other standard clutches of similar torque rating!

STEARNS STYLE SMR MINIATURE CLUTCHES

MODEL	MAX. TORQUE	DIAMETER	DEPTH	Max. V.D.C.W.	Max. Watts	Weight
5.5	**540 lb-in.**	**5⅛"**	**2 1/32"**	**115**	**26**	**12 lb.**
5	240 lb-in.	4⅜"	1 13/16"	90	12	5½ lb.
3.5	100 lb-in.	3⅛"	1 7/32"	90	11	3½ lb.
3.2	80 lb-in.	2⅞"	1 7/32"	90	9.6	3 lb.
3	60 lb-in.	2⅝"	1 7/32"	90	5.7	2½ lb.
2.5	30 lb-in.	2⅛"	1 7/32"	90	5.3	1½ lb.
2.2	8 lb-in.	1 13/16"	1 7/32"	90	4.6	20 oz.
1.8	2 lb-in.	1⅜"	29/32"	90	4.2	2¼ oz.

• For applications requiring high torque, high running speed, minimum size and weight. • Ball bearing mounted rotor, and stationary magnet body eliminate alignment problems — speed installations. • Can be supplied: 1. For 6, 12, 28, 90, 115 VDCW — class "A" through class "H" insulation. 2. With integral sprockets or sheaves. 3. To meet military specifications. 4. In split and thru-shaft arrangements. 5. In any combination of the above. 6. As magnetically set brakes, and as clutch-brake combinations.

• *Installation-Proved* — for *Assured Matched-to-the-Machine Performance and Long Life.* Request complete Clutch Data File 61C.

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN
The Complete Line of Electromagnetic Clutches — Brakes — Clutch-Brakes
SINCE 1917-THE CHOICE OF LEADING MOTOR AND MACHINERY MANUFACTURERS

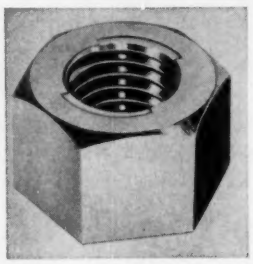
tial pressures run from a vacuum of 5 microns to 150 psi. **Skinner Electric Valve Div., Skinner Precision Industries Inc.,** New Britain, Conn.

Circle 554 on Page 19

Lock Nut

for applications having severe vibration

Uni-Torque lock nut is a one-piece, all-metal, reusable torque-type nut in which the lock is developed by deflecting the top threads slightly out of their true helix. It starts freely on the bolt until the deflected threads are reached, then requires wrenching into final position. Nut will lock in any position on bolt



provided a minimum of 1 to 1½ bolt threads protrude beyond the top of the nut. Unit assures a positive locking action in applications where there is severe vibration or heavy shock loading. It is available in a wide range of sizes and materials. **MacLean-Fogg Lock Nut Co.,** 5535 N. Wolcott Ave., Chicago 40, Ill.

Circle 555 on Page 19

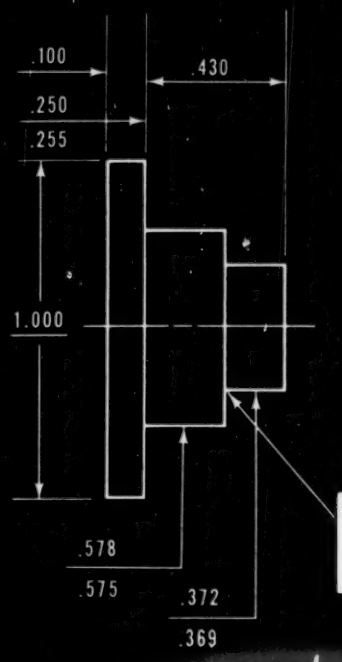
Packaged Chain, Sprockets

for small-space uses

Complete package drives of Micro-pitch bushing-type chain and sprockets are available from stock for prototypes, pilot runs, and small production runs. Infinitely variable centers possible with the 0.1475-in. pitch, stainless-steel chain permit freedom in the design of miniaturized power transmission, synchronizing, and conveying systems. Choice of 11 stainless-steel sprockets with 8 to 48 teeth permits 121 different speed ratios. When used together, chain and sprockets provide precise, nonmagnetic package drives

Circle 307 on Page 19

Circle 308 on Page 19→



inside corners

SHARP AS POSSIBLE

KEYSTONE WIRE *flowability* does it!

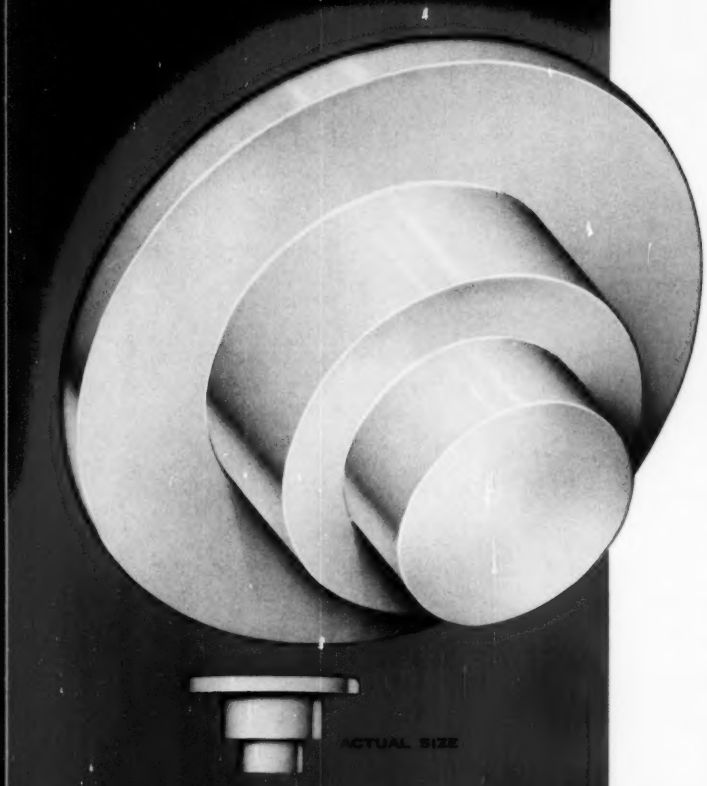
"Inside shoulders as sharp as possible," read the specifications for this shoulder rivet used in an automobile door assembly.

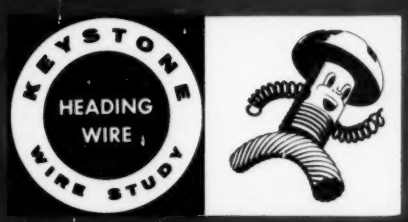
"Rockford"® Screw Products Co., Rockford, Illinois, makes this part from Keystone Direct Drawn Heading Quality Wire. In three blows, original .488″ diameter wire is extruded to .379″ diameter and severely upset to 1″ diameter. The head is consistently formed without cracking while holding to head diameter tolerances of ±.010″.

This special part, now made exclusively from Keystone Wire, is the result of extensive wire study. The flowability of this Keystone Wire allows the metal to completely fill the closed dies and achieve these sharp inside corners. Correct chemical analysis and closely controlled finish add to the successful cold heading of this shoulder rivet.

Our trained metallurgists and technicians are available to help solve your wire problems. Send us your specifications and we shall recommend the best steel analysis for you.

Keystone Steel & Wire Company, Peoria, Illinois





KEYSTONE
WIRE FOR INDUSTRY
MADE AT PEORIA, ILLINOIS, U.S.A.

Is This Job for You?

BACKGROUND—Recent degree in mechanical or electrical engineering. About three years of design-engineering experience.

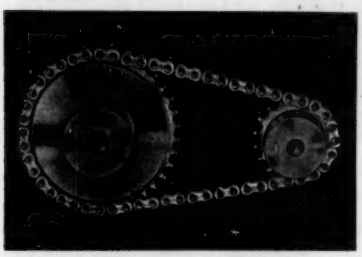
ABILITIES—Able to evaluate technical information on design techniques, new machines, components. Provable ability to write clearly and accurately. Should work well with people, have initiative and imagination, demonstrate creative as well as practical ability.

ENVIRONMENT—Cleveland, Ohio, with some out-of-town travel. As assistant editor on MD's staff of 21 engineer-editors. In Penton Publishing Company, a growth company, with 5 magazines and some 60 editors.

COMPENSATIONS—Salary comparable to that in industry. Chance to grow within the company. Unusual opportunity to broaden education, experience, and contacts. Stimulating work.

* * *

If this appeals to you not merely as a job but as the basis of a career, write at once (with all pertinent facts) to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.



suitable for small-space applications in cameras, computers, recorders, data processors, and other devices using miniature movements. **Diamond Chain Co.**, Dept. M, 402 Kentucky Ave., Indianapolis 7, Ind.

Circle 556 on Page 19

Plastic Cable Strap

mounts in blind hole

Plastic cable strap speeds the securing of wire or cable to sheet-metal surfaces in original equipment. Inserted in a blind mounting hole, strap is securely locked by thumb pressure, without tools. Metalized gray plastic construction provides high electrical protection; chemical, corrosion, and wear resistance; and high strength and vibration characteristics. Installed strap hermetically seals the mounting hole. Straps to fit various-sized mounting holes and wire or cable

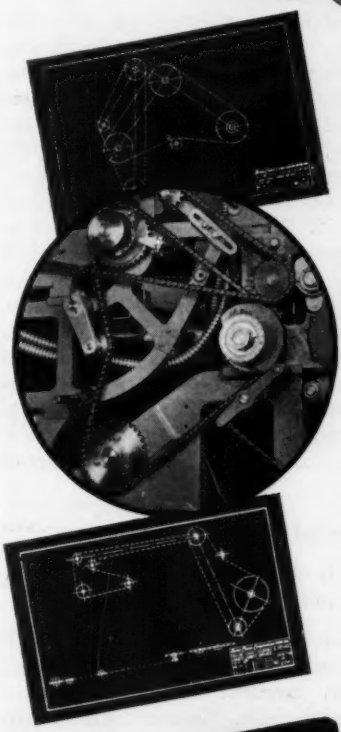
diameters are available. **Budwig Mfg. Co.**, P. O. Box 4212, Glendale 2, Calif.

Circle 557 on Page 19

Miniature Mechanisms

for airborne instruments

Miniature high-torque and flag-type mechanisms for airborne-instrument applications are highly resistant to vibration and shock. AM-50 high-torque mechanism is a self-shielding, moving-coil meter movement with internal permanent magnet. It is enclosed in a metal shell for maximum protection against dirt and damage. Mechanism can be



In engineering service and delivery from the manufacturer

Each dollar invested in Acme Chain buys the highest quality product that experience, material, design, craftsmanship and facilities can produce at competitive prices. But your dollar value doesn't end here. Acme has built its enviable reputation for giving its customers fast excellent engineering and technical service from start to finish.

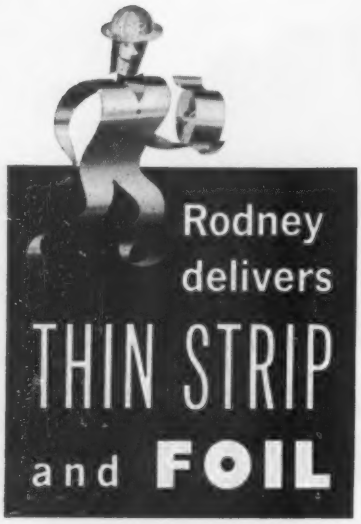
Whatever the problem, Acme's Engineering Department has always been on hand to supply its customers with a fast practical solution.

Be sure you get this extra value from every dollar you invest in roller chains. Consult your nearest Acme Distributor or write our Engineering Department for the answer to your power transmission or conveying problems.

Write Dept. 6-M for new ill. 100 page catalog with engineering section.

RELIABLE CHAIN DRIVES FOR ALL INDUSTRIES

ROLLER CHAINS, SPROCKETS, CONVEYOR CHAINS, FLEXIBLE COUPLINGS, ATTACHMENTS. (Special and Standard)



Precision Thinness in Stainless and Special Alloys...

Rodney concentrates its entire efforts, research and production, toward furnishing super thin, extra wide, precision rolled, metal strip and foil in all tempers and finishes. With the entire capacity of plant and personnel devoted exclusively to this specific area, Rodney can offer the added "know-how", manufacturing experience, quality control, and application knowledge your operation may require.

Rodney produces stainless steel strip . . . all alloys . . . in widths from ⅛" to 24" . . . at gauges from .012" to .0003". Rodney also rolls high temperature alloys and other special alloys on a production basis. Aluminum alloys, carbon steel strip and specialty custom rolling are also handled.

UNIQUE SERVICE DESCRIBED IN

FREE CATALOG

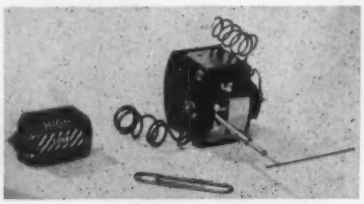
JUST DROP US A NOTE ON YOUR COMPANY LETTERHEAD

RODNEY METALS, INC.

RODNEY ROLLED IS QUALITY CONTROLLED

Mill:
Rodney French Blvd., New Bedford, Mass.
Executive Offices:
261 Fifth Avenue, New York 16, N. Y.
West Coast Office & Warehouse:
5462 East Jillson St., Los Angeles 22, Calif.

Circle 310 on Page 19



calibrated readily for a variety of scale characteristics. AM-20 flag mechanism is also self-shielding, with a moving-coil type of movement and internal permanent magnet. Designed for flight instruments, mechanism offers reliable two-position discrimination. **International Instruments Inc.**, 88 Marsh Hill Rd., Orange, Conn.

Circle 558 on Page 19

Dry-Film Lubricant

for extreme-temperature and high-vacuum service

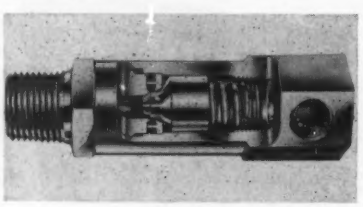
Molykote X-15 is an inorganic-bonded, dry-film lubricant with a useful temperature range of −300 to +1200 F. Lubricant is insensitive to liquid oxygen, retains its lubricating properties under vacuums to 10^{-9}mm of Hg, and is easy to apply. Starting torque of the lubricant at −100 F is 12.5 lb-in. compared to 126 lb-in. for conventional −100 F grease. Lubricant can be applied by brushing or spraying. It air dries to a tough, resilient coating in 1 hr at room temperature. Minimum shelf life is 6 months, and each package is stamped with the expiration date. **Alpha-Molykote Corp.**, 65 Harvard Ave., Stamford, Conn.

Circle 559 on Page 19

Relief Valve

is rated at 10 gpm with relieving pressure to 2000 psi

Kep-O-Seal relief valve is internally adjustable through a wide range, has excellent flow characteristics, and is quiet. Constant pressure set-



TIC OF ACTON

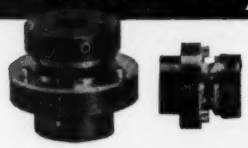
MINIATURE FLEXIBLE COUPLINGS

FEATURE • No Backlash • Compactness and Lightweight • Accommodate both lateral and angular misalignment • Choice of types offer clamping or set-screw hubs

Type MPC-1 consists of two flanged aluminum hubs and nylon or Delrin discs with V-grooves that are displaced 90° with each other. Discs are fastened with stainless steel springs loading ball pivots against V-grooves. Dimensions ⅞ x ⅞ in.
Type MPC-2 has two cylindrical aluminum hubs, each with two ball pivots attached. Hubs are attached to a pair of flexible phosphor bronze discs which hold and load the ball pivots. Dimensions ¾ x ½ in. Both types have range of bores to accept shafts from .120" to .250" and meet MIL-E-4970 and withstand −80° to 200°F and shock to 100 G.

TIC OF ACTON

ADJUSTABLE SLIP CLUTCHES



FEATURE • Adjustment over a wide torque range • Compactness and lightweight

Type ASC-1 is ⅞ x 1"
Type ASC-2 Miniature is ⅝" x ⅝"
Both are constructed of aluminum hubs, Delrin® on stainless steel clutch plates and stainless steel hardware. These rugged, high performance clutches are friction units to protect components against excessive or inertia shock loads. Range of bores to accept shafts from .120" to .250". These clutches meet MIL-E-4970 specs.

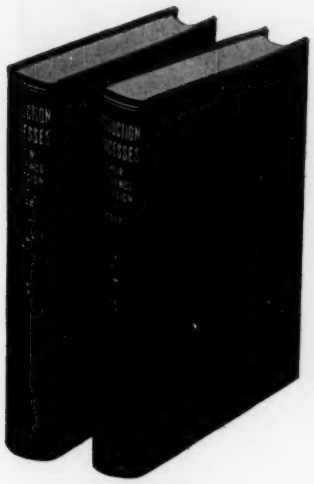
For details on couplings or clutches write

TIC OF ACTON ® DUPONT T.M.

TECHNOLOGY INSTRUMENT CORP. OF ACTON
533 Main Street
Acton, Massachusetts

Circle 311 on Page 19

DO YOU HAVE THESE TWO REFERENCE AIDS?



Two of the most important books ever written for men concerned with producibility, offer practical techniques for designing for low-cost production. In effect, these two useable encyclopedias put production know-how into the hands of product development engineers.

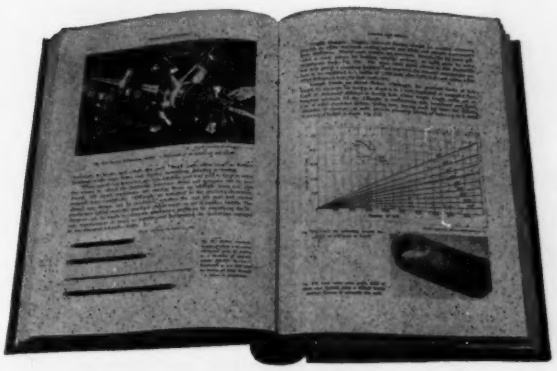
Plainly worded and clearly illustrated by one of the country's outstanding authorities on production processes, this "shop approach" to product design can be YOUR guide to lower production costs.

Inspect these books for yourself. Here are 924 pages of real dollar and cents, on-the-job help you can use for reducing production costs. Use the form below for a FREE 10-day trial.

"PRODUCTION PROCESSES"

THEIR INFLUENCE ON DESIGN VOLS. I & II BY ROGER W. BOLZ

Mass Production and Design
Metal Removal
Metal Forming
Metal Working and Forging
Metal Disposition
Coating Materials
Molding Methods
Fabricating Methods
Treating Methods



See them FREE on 10 Days Trial . . . .

Use this order form and get your set NOW!

THE PENTON PUBLISHING COMPANY, Book Department
PENTON BUILDING, CLEVELAND 13, OHIO

Send me both volumes of "Production Processes" by Roger W. Bolz

- ☐ **On 10 days trial for free examination. If the books meet with my approval I will pay $15 (plus tax, if any). Otherwise I will return the books in good condition, postpaid.**
- ☐ **Remittance enclosed* in which case the books will be sent postpaid.**
- ☐ **Bill me**
- ☐ **Bill my company**
- ☐ **C.O.D.**

NAME _____

TITLE _____

COMPANY _____

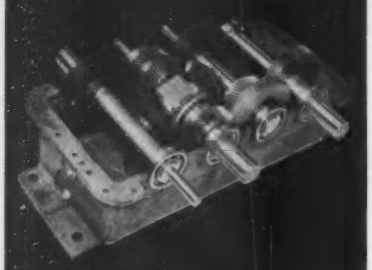
ADDRESS _____

CITY _____ **ZONE** **STATE** _____

***Please add 45c to cover State Sales Tax on orders for delivery in Ohio.**

SPECON

DIFFERENTIAL GEAR BOXES



Differential assemblies precision crafted by Specon for drives and transmissions are available as gear boxes alone. These task-proven assemblies offer the built-in advantages of Specon units: extreme accuracy, low maintenance, rugged, space saving construction. Seven basic models are rated from 1 hp. to 75 hp. Specials and units for higher power can be supplied. The Specon units are particularly well suited for such applications as phase and register control, speed control, torque dividing, overriding, cycling and balancing operations.

For full information on Specon gear boxes, drives and transmissions, write to:

STRATOS®

A DIVISION OF FAIRCHILD ENGINE AND AIRPLANE CORPORATION
Industrial Products Branch
Route 109, West Babylon, L. I., New York

Circle 312 on Page 19

ting is assured through Nylok adjustment lock for vibration resistance. Leak-tight sealing is accomplished by flexible seal seat which resists damage by contamination and wire drawing, and will not blow out. Standard valve is steel, equipped with Teflon seals, and stocked in ten connection combinations of 1/4, 3/8, and 1/2-in. dryseal pipe. All models are rated at 10 gpm with relieving pressure settings to 2000 psi. **Kepner Products Co.**, 7361 W. 59th St., Summit, Ill.

Circle 560 on Page 19

Flexible Gear Coupling

operates at speeds to 5000 rpm

Mite coupling with an all-nylon sleeve weighs 2½ oz and has an OD of 2⅞ in. Over-all length of the unit is 2⅜ in. Coupling operates at speeds to 5000 rpm and takes up to ±3 deg misalignment. It requires

no lubrication, and can run in both vertical and standard positions. Coupling is available in 3/8-in. rough bore and eight finished-bore sizes from 0.500 to 1.125 in. **Flexible Coupling Div., Sier-Bath Gear & Pump Co. Inc.**, 9254 Hudson Blvd., North Bergen, N. J.

Circle 561 on Page 19

Control Units

are suitable for use with NEMA 7 or 9 pushbutton stations

Pushbuttons, selector switches, and pilot lights of the explosionproof form are offered in a complete line for hazardous areas. Units are suitable for use with NEMA 7 or 9 pushbutton stations used where explosive gases or combustible dust are prevalent and where flame propagation must be arrested. They consist of standard and mushroom-

DEPENDABLE SWITCHING

of contact loads to 25 amps . . .

"Diamond H" Series W Relays—The simple, functional construction of this high-quality general-purpose relay assures long-time dependable switching. For a broad range of applications, specifying "Diamond H" Series W Relays makes good sense. Here are some reasons:

Reliable—Mechanical life in excess of 10,000,000 cycles.

Versatile—a-c or d-c units available with choice of eight different combinations.

Compact—Measures 1½ x 1½ x 1⅞ inches—weighs less than 10 oz.

High Contact Rating—Conservatively rated up to 25 amps, 240 v a-c or 28 v d-c.

Easy to mount—Plug-in design. Panel or side mounts also available.

Underwriters Laboratory Approval—U/L File 31481.

Cost-saving—Low in initial cost, the Series W is easy to install, saves space, and is easy to service.

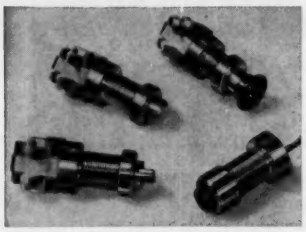
Send for complete facts—in new 8-page Series W Relay Guide.

THE HART MANUFACTURING COMPANY

118 Bartholomew Avenue, Hartford 1, Conn.
Phone JAckson 5-3491

Circle 313 on Page 19

head pushbuttons, two and three-position selector switches, and torpedo-type pilot lights. All units have silver-to-silver contact points



and carry a heavy-duty rating. Gemco Electric Co., 25685 W. Eight Mile Rd., Detroit 40, Mich.

Circle 562 on Page 19

Flexible Adhesive

bonds grill cloth to wood, plastic, or metal

Ankgrip is a fast-drying, odorfree, completely flexible adhesive available for bonding grill cloth to plywood, hardboard, plastic or metal speaker panels. Adhesive has a neutral translucent color and provides excellent adhesion to synthetic, natural, and metallic fibers used in weaving grill cloth. Nontoxic and resistant to extremes of temperature, it provides a flexible bond that withstands vibration and remains flexible for the life of the instrument. **Anchor Adhesives Corp.**, 36-23 164th St., Flushing 54, N. Y.

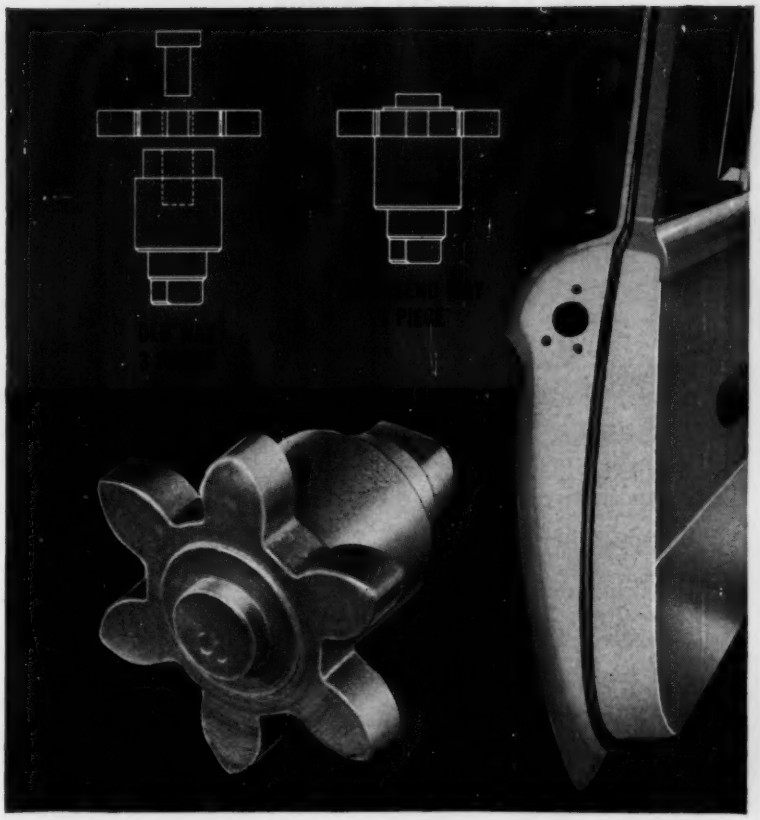
Circle 563 on Page 19

Solenoid Valves

are automatic, packless, normally closed units

Type Q and Q-1 solenoid valves, available in seven sizes from ⅜ to 2 in., are fully automatic, two-way, packless, normally closed, piston-pilot-operated units with bronze bodies. Type Q is general purpose for air and water at pressures from 5 to 400 psi, temperatures to 250 F, and steam at pressures to 15 psi over the same temperature range. Type Q-1 handles steam at pressures from 5 to 150 psi and temperatures to 365 F. **J. D. Gould Co.**, 4707 Massachusetts Ave., Indianapolis 18, Ind.

Circle 564 on Page 19



Auto maker saved $22 per thousand with Townsend Ultra-Special part

This Ultra-Special part is made by the Townsend Ultra-Special cold-forming process for $22 less per thousand pieces than the former three-piece assembly made by another method.

One of these automobile door latch rotors is used in each car door by a major manufacturer. Their annual savings—by using this part—is quite substantial.

Cold forming adds strength to make a tougher part while holding dimensional tolerances. In developing these Ultra-Special parts, Townsend's engineers combine such processes as cold-heading and impact extrusion—or, interim heat treatments and coatings. The result is an extended range of standard production equipment far beyond ordinary limitations.

You benefit directly by using Townsend Ultra-Special parts in the assembly of your products. Your increase in profit potential is a direct combat to competition. A Townsend engineer will be happy to discuss your production assembly. Write Townsend Company, P. O. Box 71-E, Ellwood City, Pa.

Townsend Company

ESTABLISHED 1816

Engineered Fasteners Division

ELLWOOD CITY • PENNSYLVANIA

In Canada: Parmenter-Bulloch Manufacturing Co., Limited, Gananoque, Ontario

Circle 314 on Page 19

NOW AVAILABLE

TWO HELPFUL BOOKLETS ON ELECTRIC MOTORS AND POWER SUPPLIES

1. Electronic and Electric Power Supplies

A symposium of six articles on the selection, specification and application of—

- Electronic Power Supplies
- AC and DC Electric Generators
- Lightweight Electric Generators
- Generator-Battery Systems
- Vibrator and Dynamotor Power Supplies
- Dry Cells and Storage Batteries

$1.00 a copy

2. Special Report on Electric Motors

Including a 10-page Directory of 140 motor and gearmotor manufacturers, classified according to the types of motors produced.

A comprehensive review of the design advances in electric motors, with special articles written by authorities in the areas of fractional and integral horsepower motors.

$1.00 a copy

MACHINE DESIGN READER SERVICE

Penton Building
Cleveland 13, Ohio

Remittance or Company Purchase Order must be enclosed with order

Name
Company
Address
City Zone State

Send me____copies of Power Supplies
Send me____copies of Electric Motors

(Add 3% to orders in Ohio to cover State Sales Tax)

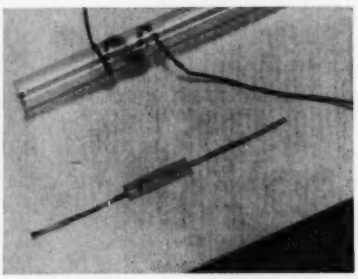
ENGINEERING DEPARTMENT

EQUIPMENT

Solid-State Strain Gages

have high output and resolution

Series DB solid-state strain gages include matched gages for a variety of materials, gages for dynamic measurements which provide high output, small gages for limited space requirements (0.1-in. gage length), and gage factors from −140 to



+170. Gages are incorporated in a highly flexible epoxy matrix, and are available in resistance ranges of 120 to 5000 ohms. **Kulite-Bytrex Corp.**, 50 Hunt St., Newton 58, Mass.

Circle 565 on Page 19

Pencils and Leads

for use on drafting film

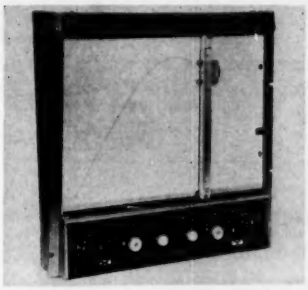
Damascus Polyfilm drawing pencils and leads are available for use on Mylar, Estar, and Cronar polyester-base drafting films. Pencil is available in five degrees of hardness, and features Try-Rex pencil shape. Leads are also available in five degrees of hardness. **Richard Best Pencil Co. Inc.**, Mountain Ave., Springfield, N. J.

Circle 566 on Page 19

X-Y Recorders

draw curves automatically from dc electrical information

Two 11 x 17-in. Autograf X-Y recorders are designated Models 2D-2 and 2DR-2 (shown). The latter is



rack mounted; former is a cabinet instrument which accommodates continuous chart rolls in a variety of transport methods. Models draw Cartesian co-ordinate curves automatically from dc electrical information, and also plot one variable against time. They are compatible with data-reduction equipment and operate directly from a variety of accessories. Input voltage ranges are calibrated in 16 steps from 0.5 mv to 50 v per in. on each axis. Both models feature built-in vacuum paper hold-down and have pen speeds of 20 ips for each axis. **F. L. Moseley Co.**, 409 N. Fair Oaks Ave., Pasadena, Calif.

Circle 567 on Page 19

Cryogenic Sensors

measure temperatures as low as −269 C

Two small cryogenic sensors are germanium semiconductors designed for application in test and operational phases of space vehicles using liquid helium and nitrogen, and for use in calibration and standards laboratories. Temperature range is 4 to 40 K (−269 to −233 C). One unit (left) measures surface temperatures; the other is a probe-type sensor for internal applications. Both are encapsulated and hermetically sealed. Thermometer elements are precision doped to provide high thermometric sensitivity. Sensors can be used with conventional milli-

What's so unusual about a laundry tub?

This **particular** tub was molded of **Fiberglas** reinforced plastics using the new **premix** process pioneered by **AICO**. It has an unusually **smooth** finish, is exceptionally **strong** and is unusually **low** in costs. The new **premix** process opens up **many** new opportunities to use reinforced **plastics**. Why not see if you can't capitalize on it, too.

PRECISION MOLDED PLASTICS AICO SINCE 1916

AMERICAN INSULATOR

New Freedom, Pa.

Where tomorrow's plastics are now being molded

Circle 315 on Page 19

Standard
high speed coupling.

standard: 20,000 rpm
special: 70,000 rpm

Waldron high speed gear couplings are made with special care to prevent vibration—the usual troublemaker at high speeds. All parts are machined and inspected to close tolerances. Every assembled coupling is dynamically balanced on an arbor. Forged alloy steel gives them reliable strength, and they can be furnished grease-packed or continuously lubricated. Write for bulletin S-1500.

Standard size	HP/100 rpm	Max. rpm	Max. bore
1½ HS	19	20,000	1½
2 HS	24	18,000	2
2½ HS	50	15,000	2½
3 HS	87	12,500	3
3½ HS	125	11,000	3½
4 HS	210	9,500	4
4½ HS	305	8,500	4½
5 HS	410	7,500	5
5½ HS	550	6,500	5½
6 HS	675	6,000	6

WALDRON-HARTIG, Box 791, New Brunswick, N. J.
a division of Midland-Ross Corporation

WALDRON
Makes it easy to pick the right
Couplings

Circle 316 on Page 19

volt-type instruments. **Primary Sensors Dept. C189, Minneapolis-Honeywell Regulator Co.,** Wayne & Windrim Avenues, Philadelphia 44, Pa.

Circle 568 on Page 19

Magnetic Tape Recorder

miniature unit has speeds of 1.875, 3.75, 7.5, 15 ips

Model CC-90 miniature, continuous-loop magnetic tape recorder records and reproduces data on 1 to 14 channels under severe environmental and limited space conditions. Unit is available in tape speeds of 1.875, 3.75, 7.5, and 15 ips, with

up to 12-ft loop. Small, lightweight unit has a 3-in. diam and is 3 in. long, weighing less than 1 lb. Four tapped holes are provided for mounting on the standard unit. **Aero Data Corp., Div., American Concertone Inc.,** 9449 W. Jefferson Blvd., Culver City, Calif.

Circle 569 on Page 19

Pressure Transducers

measure high or low pressures at 600 F

Small, lightweight P732 pressure transducers, of stainless-steel construction, are temperature-compensated for continuous operation to 600 F. Ambient temperature limits are −320 to +650 F. Pressure ranges on the gage and unidirectional differential models are from 0-2 through 0-5000 psi. Bidirectional differential model operates in ranges from ±1 through ±100 psi. Combined nonlineary and hysteresis are less than ±0.75 in both high and low-pressure ranges. **Statham Instruments Inc.,** 12401 W. Olympic Blvd., Los Angeles 64, Calif.

Circle 570 on Page 19

THE ENGINEER'S

Library

Recent Books

Theory of Hydrodynamic Lubrication. *By Oscar Pinkus; 465 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN; *$15.00 per copy postpaid.*

This comprehensive treatment of hydrodynamic and hydrostatic lubrication emphasizes design problems and applications. Specific problems discussed include hydrodynamics of simple configurations, one-dimensional bearings, finite bearings, hydrodynamic gas bearings, hydrostatic bearings, squeeze film and dynamic loading, hydrodynamic instability, and inertia and turbulence effects. A formulation of the differential equations of lubrication is offered with techniques for solving these equations either analytically or by analogues and digital computers.

Handbook of Mechanical Wear. *Edited by Charles Lipson and L. V. Colwell; 469 pages, 6¾ by 10 in., clothbound; published by The University of Michigan Press, 3564 Administration Bldg., Ann Arbor, Mich.; available from* MACHINE DESIGN, *$20.00 postpaid.*

A collection of sixteen papers on wear of metal parts and products is presented in six parts: Fundamentals; pitting, scoring and spalling; corrosion; abrasion; wear-resistance materials; and manufacturing processes. Specific topics include sliding characteristics of metals at high temperatures, subsurface fatigue, resistance of materials to rolling loads, galvanic corrosion, pitting of gear teeth, corrosion at high temperatures, and wear resistance of cast-iron components.

Cybernetics Without Mathematics. *By Henryk Greniewski; 201 pages, 5½ by 8½ in., clothbound; published by Pergamon Press Inc., 122 East 55th St., New York 22, N. Y.; available from* MACHINE DESIGN; *$6.00 per copy postpaid.*

The foundations of cybernetics

15
WHAT DEPENDABLE
SLIDE SWITCHES
CAN DO FOR YOUR PRODUCTS
ADD COLOR—Trigger knobs in 10 attractive colors add decorative and functional touches to switching operations.
CUT COSTS—Low in initial cost, Stackpole Slide Switches often reduce costs up to 50% over other type switches.
SAVE SPACE—Stackpole Slide Switches take less panel area, often less depth than conventional switches.
SIMPLIFY PRODUCTION—Choice of solder lug or printed wiring terminals, clearance or tapped-extrusion mounting holes.
HANDLE HIGHER LOADS—0.5- to 1-amp types for electronic equipment. 1-, 3-, and 6-amp types for appliances and power tools.
SWITCH COMPLEX CIRCUITS—1- to 3-poles, 2- to 4-positions for real switching versatility.
FACILITATE OPERATION — Trend-setting slide action available with or without detents and spring returns. Plunger-operated and matching pushbutton styles also available.
Write for Slide Switch Bulletin
STACKPOLE
ELECTRONIC COMPONENTS DIVISION
STACKPOLE CARBON COMPANY, St. Marys, Pennsylvania

Circle 317 on Page 19

HYDRAULIC SERVO FUNDAMENTALS

by J. M. Nightingale

VOL. 1

Covers both the theoretical and practical aspects of servo system design applicable to control systems in general—hydraulic, pneumatic or combined systems.

$1.00 per copy

VOL. 2

Study of the basic servo system components and practical methods for analyzing typical servo systems.

$1.00 per copy

VOL. 3

A detailed approach to methods of improving servo system performance, quantitative design of servo systems and transient response of servo systems.

$1.00 per copy

MACHINE DESIGN
Reader Service
Penton Building
Cleveland 13, Ohio

Send me_____copies of Vol. I @ $1.00 per copy
Send me_____copies of Vol. II @ $1.00 per copy
Send me_____copies of Vol. III @ $1.00 per copy

Remittance or Company Purchase
Order must be enclosed with order

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE ____ STATE ____

(Add 3% to orders in Ohio to cover State Sales Tax)

are outlined from a presentation made at the First International Cybernetical Congress at Namur in 1956. The basic concept is that of a relatively isolated system; topics covered include stimulus and reaction, prospective reliable systems, reaction time, determinators and paradeterminators, duality, negative feedback, positive feedback, and inputs, outputs and throughputs. Separate chapters are devoted to signals and expressions, codes and languages, logical models, and economic models.

The Impact of the Professional Engineering Union. *By Richard E. Walton; 419 pages, 5¼ by 8 in., clothbound; published by Division of Research, Graduate School of Business Administration, Harvard University, Boston, Mass.; available from* MACHINE DESIGN, $5.00 *postpaid.*

This book reports on research into the experiences of 11 companies where professional engineers and scientists have organized certified bargaining units. The impact of the union on work assignments, management organization, and employee relations is discussed.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

TN D-796. Residual Static Strength of Aluminum-Alloy Box Beams. By Herbert A. Leybold; 25 pages, 8 by 10½ in., paperbound, stapled; $0.75 per copy.

Static tests were performed on 31 box beams containing fatigue cracks to determine residual static strengths. Beams were constructed of 7075 and 2024 aluminum alloy in several designs and employed stringers either bonded, riveted or an integral part of the skin. For the integrally stiffened beams, crack propagation and failure were simultaneous.

PB 161556. Investigation of Bearing Creep of Two Forged Aluminum Alloys. By Leonard Mordfin, Nixon Halsey, and Philip J. Granum; 32 pages, 8 by 10½ in., paperbound, stapled; $1.00 per copy.

A limited test program was undertaken to obtain data on bearing creep deformation for 7075-T6 and 2014-T6 forged aluminum alloys. Objective was to examine feasibility of calculating creep deformations in large bolted joints expected to fail in bearing.

TN D-882. Stress Concentrations in Filamentary Structures. By John M. Hedgepeth, Langley Research Center; 30 pages, 7¾ by 10¼ in., paperbound, stapled; $0.75 per copy.

Theoretical analysis is made of stress distributions in a sheet of parallel filaments. Uniform loading at infinity is assumed and small-deflection elasticity theory is used. Particular attention is given to dynamic overshoot when filaments are suddenly broken.

TR R-103. Theoretical Elastic Stress Distributions in Several Shell-Type Structures. By Robert H. Johns and Thomas W. Orange, Lewis Research Center; 63 pages, 7¾ by 10¼ in., paperbound, stapled.

Deformation and stress distribution are determined for three edge-loaded thin shells: Right circular cylinder, frustum of right cylinder cone, and portion of a sphere. Locations of maximum circumferential and meridional stresses are included.

REPRINTS

Complete reprints of major article series and collections of articles, and extra copies of MACHINE DESIGN *Books*, are available from: Reader Service, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio. Remittance or company purchase order must be enclosed with your order. Add 3 per cent to orders in Ohio to cover State Sales Tax.

The Bearings Book, 1961 Edition (256 pp.) $2
The Seals Book, 1961 Edition (240 pp.) $2
The Fasteners Book, 1960 Edition (236 pp.) $2
Preventing Fatigue Failures, by F. B. Stulen, H. N. Cummings, W. C. Schulte, 1961 (32 pp.) $1 (available Aug. 1)
Simplified Vibration Analysis by Mobility and Impedance Methods, by R. P. Thorn & A. H. Church, 1959-1960 (80 pp.) $2
Inside the Engineer, by Eugene Raudsepp, 1958-1960 (52 pp.) $1
Mobility of Cross-Country Vehicles, by M. G. Bekker, 1959-1960 (32 pp.) $1
Engineering Approach to Hydraulic Lines, by Jaroslav J. Taborek, 1959 (36 pp.) $1
Planning New Products, by Philip Marvin, 1953-1958 (102 pp.) $3
Friction-Clutch Transmissions, by Z. J. Zania, 1958 (30 pp.) $1
Design Guide—Flexible Couplings, by Leo F. Spector, 1958 (128 pp.) $1
Special Report on Electric Motors, Staff Report, 1958 (42 pp.) $1
Electronic and Electric Power Supplies, (Symposium) 1958 (40 pp.) $1
Human-Factors Engineering, by J. D. Vandenburg and C. T. Goldsmith, 1958 (32 pp.) $1
Mechanics of Vehicles, by Jaroslav J. Taborek, 1957 (94 pp.) $2
Design for Fatigue Loading, by Joseph Marin, 1957 (34 pp.) $1
Hydraulic Servo Fundamentals, by J. M. Nightingale.
Volume 1: May-Nov., 1956 (32 pp.) $1
Volume 2: Nov., 1956—Mar., 1957 (30 pp.) $1
Volume 3: May, 1957—Feb., 1958 (44 pp.) $1
Adjustable-Speed Drives (Electrical-Mechanical-Hydraulic), Staff Report, 1954-1955 (146 pp.) $2
MACHINE DESIGN Data Sheets
1960 (130 pp.) $2
1959 (136 pp.) $2
1958 (132 pp.) $2
1957 (102 pp.) $2
1956 (114 pp.) $2
Transactions of the Mechanisms Conferences
Sixth Conference, 1960 (152 pp.) $2
Fifth Conference, 1958 (240 pp.) $3
Fourth Conference, 1957 (104 pp.) $2
Third Conference, 1956 (40 pp.) $1
Second Conference, 1954 (50 pp.) $1
First Conference, 1953 (48 pp.) $1
Tips and Techniques
Vol. 1—Drafting Aids, 1956-1957 (32 pp.) $1
Vol. 2—Engineering Aids, 1956-1958 (30 pp.) $1

With PC working for you, size is no longer a barrier to investment casting in production quantities, whether the part weighs 75 lbs. (*shown above*) or decimal ounces (*below*) or involves melts up to 300 lbs. using air, inert atmosphere, or vacuum techniques.

Advanced methods, skilled personnel, and the most modern investment casting facilities bring PC customers from East, West, North and South.

PC's *complete* and integrated services include: CONSULTATION DESIGN • TOOLING • PRODUCTION • HEAT TREATING NON-DESTRUCTIVE & METALLURGICAL TESTING • MACHINING

PRECISION CASTPARTS CORPORATION
4602 S.E. Harney Drive
Portland 6, Oregon
PRospect 5-4391

Represented nationally by:
District Sales Corp., ANgelus 3-2149
Los Angeles 22, California
ESCO, DUdley 8-5901
Denver 7, Colorado
ESCO, Hickory 6-2210
Danville, Illinois
ESCO, ORegon 9-3240
New York 17, New York
John Lobb, MOhawk 4-0740
Bellaire 101, Texas

. . . or Investment Castings— LITTLE

Circle 318 on Page 19

A series of unique articles outlining the steps in . . .

This 102 page volume includes practical data on:

- Measuring company needs in new-product development
- Developing and finding new-product ideas
- Evaluating new-product potentials
- Organizing engineering and research for product development
- Measuring progress in product performance

MACHINE DESIGN

Reader Service, Penton Building, Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order.)

Send me_____copies of

Planning New Products @ $3.00 each

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

(Add 3% to orders for delivery in Ohio to cover State Sales Tax.)

This collection of 17 helpful articles details the necessary steps to the development and engineering of new products. Written by Dr. Philip Marvin, well-known management authority, this book is "required reading" for *every* engineer responsible for the development of new product ideas or the operation of a research program.

A

MACHINE DESIGN

REPRINT

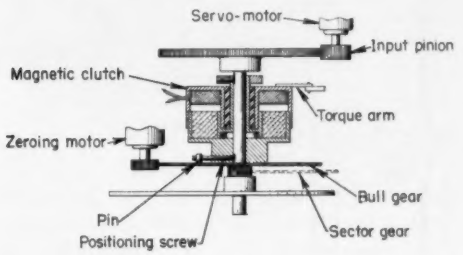
MAIL TODAY

NOTEWORTHY

Patents

Signal Converter

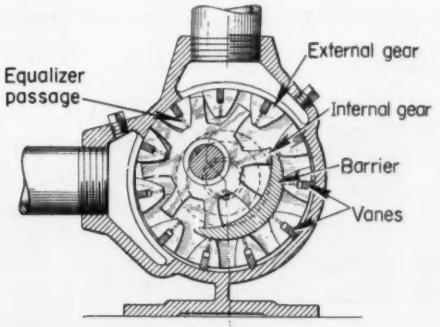
Periodic electrical signals are converted into pneumatic equivalents by a signal translating system. Servo motor transmits input signals to a gear and magnetic-clutch assembly. Rotational movement of a bull gear actuates a sector gear to control output pressure of a



pneumatic regulator. A pin within the clutch assembly is selectively positioned inward or outward for cumulative or individual signal rotation as required. The gears are reset by a zeroing motor according to a predetermined program sequence. *Patent 2,982,292 assigned to Union Carbide Corp., New York, by Sterling T. Martin.*

Wear-Compensated Pump

Wear between the external gear and pump housing in an internal-external gear pump is automatically compensated by vanes to minimize pressure loss. The internal gear, mounted to a stub shaft, is eccentri-



cally positioned to mesh with the external gear which is keyed to the drive shaft. Vanes housed within each gear tooth of the external gear are forced outward against the housing wall by centrifugal force. To prevent partial vacuum within the vane slots, pressure-equalizing passages are provided through each

ALL-STATIC LIMIT SWITCHES

CONTROL MAGNETIC MATERIALS WITHIN ±.001 INCH

Here's a new line of proximity limit switches which enable you to control magnetic materials movement within thousandths of inches in many applications. So sensitive that it is actuated by parts as small as ¼" cubes, yet remains equally sensitive, with pieces hundreds of times as large.

OPERATING PARAMETERS:

Two operating distances: Adjustable ¼" - ½"; ¼" - 2". 5-20 operations per second. Response time, 25 milliseconds. Sensitivity to turn off: 20% at maximum trip distance; 5% at minimum trip distance. Control element output: 8 w, 24 v d-c at 335 ma, 60 cps.

Reliable · Rugged · Corrosion Resistant · Can't wear out.

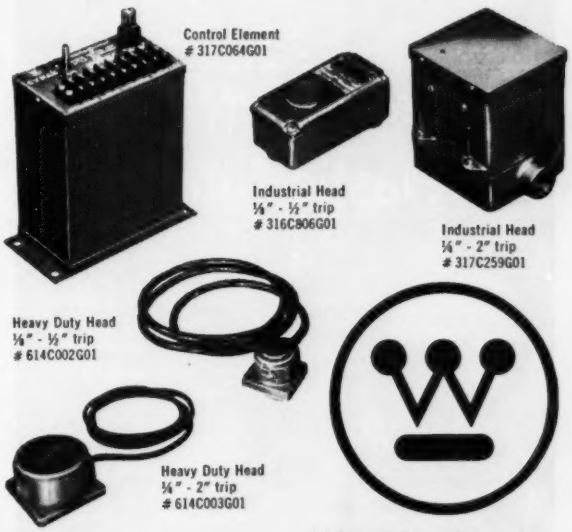
Not affected by oil mist, iron filings, sand, dust, dirt or water. Has passed Navy shock and vibration tests (MIL-S-901B) and (MIL-STD-167).

Consider the many places these sensitive, reliable switches can be used in your laboratory or production installations. They are simple to install, easy to apply. They include only three parts: the sensing head located where the magnetic pieces will actuate the element when brought within the predetermined trip distance; the control element (can be located anywhere) which picks up the signal from the head to actuate relays, solenoids or other static components; the 115v, 60c supply line and head-to-element lead.

Normally each sensing head requires its own control element, although up to six heads can be used on a single element in special applications.

For specific or test applications, send your order or request for further technical information direct to General Purpose Control Dept., P.O. Box 2025, Buffalo 5, N.Y.

You can be sure . . . if it's Westinghouse.



Westinghouse

J-25010

Westinghouse Electric Corporation
General Purpose Control Dept., P.O. Box 2025, Buffalo 5, N.Y.

☐ Please send technical information

Please send the following units: ☐ 317C064G01 ☐ 3160806G01 ☐ 317C259G01 ☐ 614C002G01 ☐ 614C003G01.

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

Circle 319 on Page 19

SYNFLEX
Pressure Hose

Improved
hydraulic hose
incorporating precision
drawn nylon inner tube, nonmetallic reinforcing
braid, abrasion-resistant extruded cover. Electrical non-conductor.

■ **Synflex Pressure Hose** is a new concept in high pressure hose for multi-purpose applications. Combines strength with light weight . . . no metal to fatigue . . . low cost. Use with water, fuels, oils, gases, solvents, refrigerants, conventional and non-flammable hydraulic fluids. Available with reusable couplings in a range of sizes from 3/16 thru 3/4 ID and larger.

Specify SYNFLEX
Plastic Tubing

V • 1 CLEAR VINYL
Glass-clear . . . non-toxic . . . odorless and tasteless . . . flexible yet tough . . . easy to clean or steam sterilize . . . never kinks. Sizes: 1/8 thru 3/8 ID in 1/16 increments, all with 1/16 wall.

P • 1 POLYETHYLENE
Precision extruded to closest tolerances . . . high molecular weight . . . virgin resin free from impurities or imperfections. Natural and 7 fade resistant colors. Sizes: 1/4 OD with .040 wall, 3/8 and 1/2 OD with .062 wall.

N • 3 NYLON HYDRAULIC-PNEUMATIC
Ideal pressure tubing made from precision extruded nylon . . . strong and flexible . . . superior fatigue, corrosion and abrasion resistance . . . installs fast. Sizes: 1/8 thru 3/8 in various wall thicknesses.

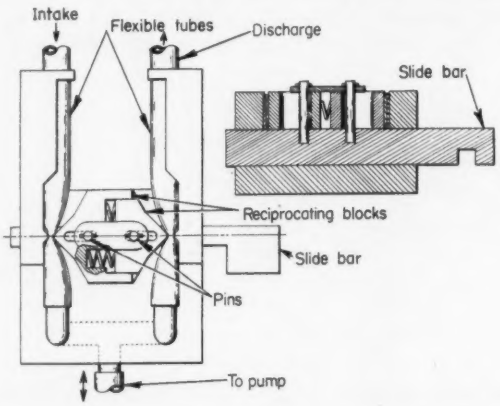
A-26MA

SYNFLEX
Products Div.
Samuel Moore & Co.
Mantua, Ohio

tooth to the pumping chamber. *Patent* 2,983,228 *assigned to Viking Pump Co., Cedar Falls, Iowa, by Anthony A. Wagner.*

Double Pinch Valve

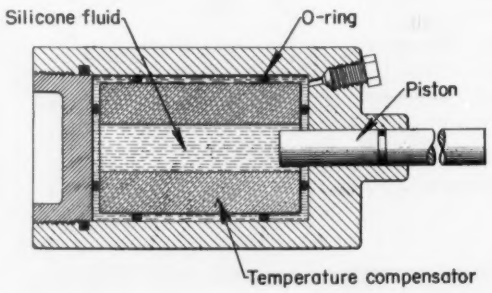
Measured volume of liquid is repeatedly supplied by the synchronous action of a double-pinch valve and reciprocating pump (not shown). Opening and closing of each flexible tube in the valve is controlled by a slide bar (actuated through the pump crankshaft)



and double-block assembly. Thus, with each intake and discharge cycle of the pump, the V-shaped valve blocks alternately pinch the intake and discharge tubes. At no time during the pumping cycle are both tubes simultaneously open. Therefore, the pump can be stopped in any position without leakage through the valve. *Patent* 2,985,192 *assigned to American Cyanamid Co., New York, N. Y., by Arthur Sinclair Taylor.*

Temperature-Compensated Liquid-Spring

A liquid spring is temperature compensated by a cylindrical insert of constant volume, such as Pyrex glass or quartz. Compensation is achieved by proportioning the relative volumes of chamber, compressible

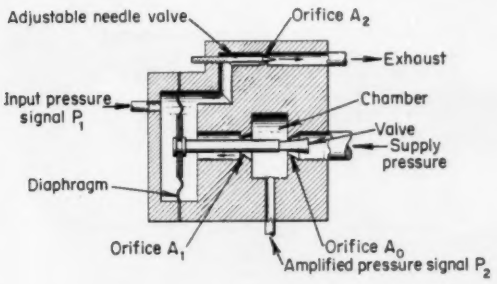


liquid, and compensator insert according to their coefficients of expansion. For example, if the liquid coefficient of expansion is ten times that of the chamber, filling 90 per cent of the chamber with the Pyrex insert results in equal volumetric change. Effective chamber volume is total chamber volume minus com-

pensator volume and varies with temperature at substantially the same rate as the liquid. *Patent* 2,982,537 *assigned to Houdaille Industries Inc., Buffalo, N. Y., by Rollin Douglas Rumsey.*

Pressure-Signal Amplifier

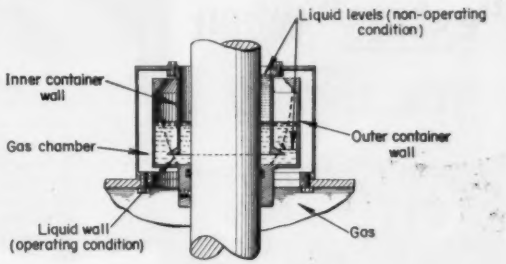
A simplified pressure-signal amplifier uses three orifices in series. Continuous pressure is fed into a passageway containing the orifices. A single diaphragm is actuated by the pressure between the last two



orifices on one side and the input pressure signal on the other side. Diaphragm movement positions a valve to adjust the area of the first orifice and the resultant amplified pressure signal is obtained between the first two orifices. Upon any change in pressure signal, valve position will change to maintain a pressure balance on the diaphragm. Amplification ratio is altered by varying the orifice areas. *Patent* 2,982,293 *assigned to The Marquardt Corp., Van Nuys, Calif., by Howard C. Dillon.*

Vapor Seal

A shaft seal prevents escape of hazardous vapors during either stable rotation or eccentric gyration of a spindle. Seal consists of inner and outer containers adapted to hold a body of liquid. With spindle ro-

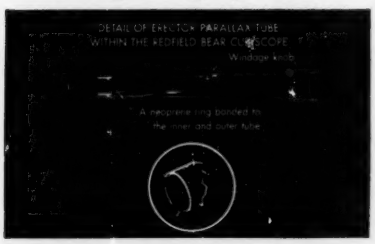


tation, liquid is forced outward by centrifugal force forming a vertical parabolic-shaped wall as indicated by the broken lines. When the spindle is at rest, vapor pressure displaces the liquid downward in the outer container and upward in the inner container forming a column between the inner container wall and spindle. Thus, sealing action is maintained under

With Eastman 910 Adhesive...

Strong neoprene-to-aluminum bonds in 2 minutes

Take two aluminum tubes, one smaller than the other. Put one inside the other. At one end only, bond a neoprene ring between the two tubes. Got it? How long did it take you? Ames Rubber Company, of Hamburg, New Jersey, does it in two minutes when assembling the Redfield Gunsight Company's "Bear Cub Scope," a precision telescopic rifle sight. Ames uses Eastman 910 Adhesive. Over 25,000 units have been produced with no reports of bond failure.


DETAIL OF ERECTOR PARALLAX TUBE WITHIN THE REDFIELD BEAR CUB SCOPE
Windage Knob
A neoprene ring bonded to the inner and outer tube

Eastman 910 Adhesive will form bonds with almost any kind of material... fast, too.

Skeptical? Then send $5 for a trial kit and try it on *your* toughest job. Kits and further information are available from Armstrong Cork Company, Industrial Adhesives Division, 9107 Dean Street, Lancaster, Pa., or Eastman Chemical Products, Inc., Dept. M-7, Kingsport, Tennessee.

Here are the types of bonds that can be made with Eastman 910 Adhesive

Among the stronger: *Natural rubber, SBR, Buna N, most types of neoprene, steel, aluminum, brass, copper, most woods, vinyls, phenolics, cellulosics, polyesters, polyurethanes,* and *nylon.* Among the weaker: *polystyrene, polyethylene* and *fluoro-hydrocarbon plastics* (sheer strengths up to 150 lbs./in.²).

There is no adhesive like Eastman 910 Adhesive

Sets fast—Makes firm bonds in seconds to minutes.

Versatile—Joins virtually any combination of materials.

High strength—Up to 5,000 lbs./in.² depending on the materials being bonded.

Ready to use—No catalyst or mixing necessary.

Cures at room temperature—No heat required to initiate or accelerate setting.

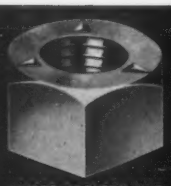
Contact pressure sufficient.

Low shrinkage—Virtually no shrinkage on setting as neither solvent nor heat is used.

Goes far—One-pound package contains about 14,000 one-drop applications.

The use of Eastman 910 Adhesive is not suggested at temperatures above 175°F., or in the presence of extreme moisture for prolonged periods.

See Sweet's 1961 Product Design File 10d/Ea.



GRIPCO TOPLOCK NUT
One piece all metal.

GRIPCO CLINCH NUT
With or without self-locking threads. Hex collar prevents turning when torqueing bolt.

GRIPCO PILOT-PROJECTION WELD NUT
With or without self-locking threads. Centering collar positions nut and protects threads from weld spatter.

You get these "extras" when you specify

GRIPCO®

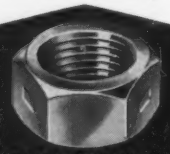
FASTENERS—

Service **—40 sales representatives all over the country for prompt, fast service.**

Reliability **—Quality controlled by the oldest established lock nut manufacturer in the U.S.**

Stock **—Large inventories to ensure out of stock delivery on all catalogued items.**

Speed production and lower costs on your products with this GRIP NUT family of GRIPCO FASTENERS. Qualified fastener engineers are available for consultation on all your assembly problems. Consult the yellow pages in your phone book under "GRIPCO" for the one nearest you.



GRIPCO CENTERLOCK NUT
Locking feature in the center for fast feeding. Can be applied from either end.

GRIPCO COUNTERSUNK WELD NUT
With or without self-locking threads. Countersink protects threads from weld spatter.

Other Gripco Products:

- Brass Toplock or Centerlock nuts.
- Miniature weld and clinch nuts, with or without lock.
- Toplock and Centerlock Hi Nuts.
- Standard Semi-finish full and jam nuts.
- Stainless Steel lock, weld and semi-finish nuts.
- Cold formed special nuts or parts to print.

Send for samples and NEW CATALOG today

GRIP-NUT COMPANY 125

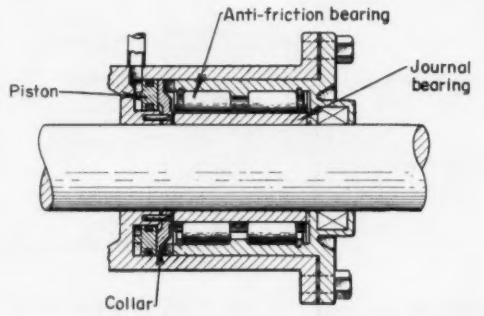
103 MAPLE AVE.
SOUTH WHITLEY, INDIANA
Phone: South Whitley 723-5111

Subsidiary of Heli-Coil Corporation, Danbury, Conn.

all conditions of operation. *Patent* 2,982,417 *assigned to The Western States Machine Co., Hamilton, Ohio, by Harold Durrell.*

Composite Bearing

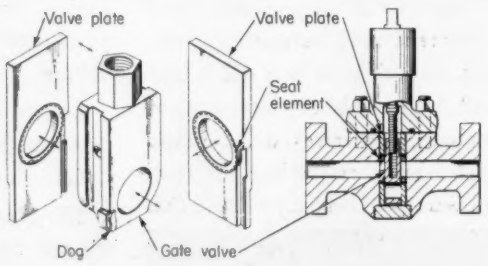
A composite bearing assembly, composed of a journal bearing housed within an antifriction bearing, provides automatic selective operation according to shaft speed. Upon initial rotation of the shaft and at low speeds, the



antifriction bearing is employed. Then, as the shaft speed increases, the journal bearing is made operative. Selective operation is accomplished through a fluid pressure operated clutch. *Patent* 2,986,430 *assigned to Aerojet-General Corp., Azusa, Calif., by Gordon Banerian.*

Rotating Valve Seat

Distributed wear is provided in a gate valve by incremental rotation of a seat element. Rotation is imparted by valve movement with each opening and closing cycle. On opening, a dog mounted on the gate



pivots to engage a tooth of the seat element causing it to rotate a predetermined amount. Movement of the valve to the closed position disengages the dog for the next rotation. *Patent* 2,977,976 *assigned to Cameron Iron Works Inc., Houston, Texas, by Herbert Allen.*

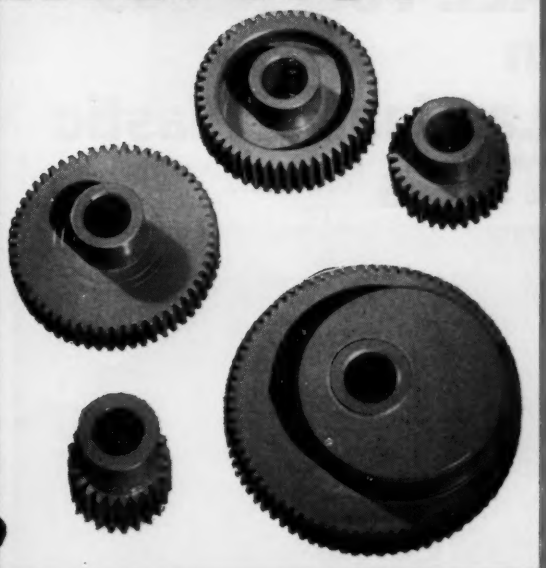
Inducer for centrifugal pump increases pressure of incoming fluid to the pump impeller by creating a swirling vortex pressure pattern. This pattern permits higher suction speeds to be attained before incipient cavitation occurs in the impeller suction eye and pump

THE AMPLEXOLOGIST

dreams up a gear train

The Amplexologist designed this gear train (plus ten other parts) especially for powder metal production—at the request of a manufacturer who called him in at the design stage. All (except the helical gear) are finished precision parts which require only shaving. Estimated savings; 86%. Sound interesting? Call the Amplexologist.

AMPLEX
DIVISION
CHRYSLER
CORPORATION
DETROIT 31, MICHIGAN
OILITE



SEND FOR THE SECRET OF THE AMPLEXOLOGIST'S SUCCESS

1 ENGINEERING MANUAL
45 pages of technical information: How to determine correct applications for powder metal parts, bearings, filters.

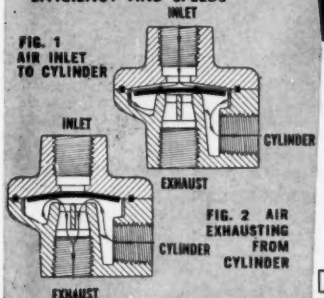
2 NEW BEARING STOCK LIST
20 pages. 1066 standard sizes of Oilite self-lubricating bearings—bearing material. Selection guide, engineering data.

Circle 323 on Page 19

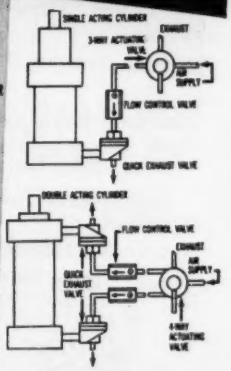
NEW! Pneu-trol® QUICK EXHAUST VALVE

Fast air dumping AT THE CYLINDER permits use of smaller valves and piping . . . INCREASES EFFICIENCY AND SPEEDS

Operating Pressures:
1 to 125 PSI
For 3/8" and 1/4" pipe sizes



When control valve is opened air pressure seals exhaust port and diaphragm is deflected permitting air to pass thru the cylinder port (Fig. 1). When inlet pressure is relieved (by actuating valve in control circuit) the buildup of cylinder return pressure closes inlet port (Fig. 2) snapping the diaphragm off the exhaust port allowing instantaneous evacuation of exhaust air. *Write for complete details, specifications and prices.*



TYPICAL APPLICATIONS of Quick Exhaust Valves in Single and Double Acting Cylinders. Because exhaust air is dumped at cylinder, smaller diameter piping and smaller selector valves can be used.

AUTOMATION AUTO-PONENTS INC COMPONENTS

AUTO-PONENTS INC.
2925 Grant St. • Bellwood, Illinois

Circle 324 on Page 19

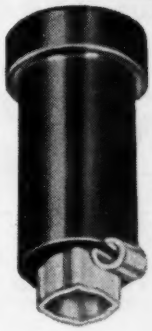
If you break your arm
see a DOCTOR

BUT...if you need a

BRUSH HOLDER

Your SPECIALIST is

PHOENIX



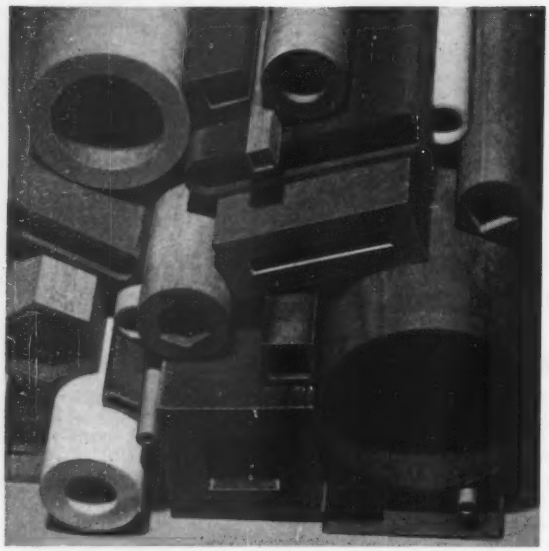
- Offers Complete Line of Brush Holders and Caps
- For All Types of Motors and Generators
- A Competent Engineering Department To Assist in Brush Holder Requirements
- 25 Years of Experience

Write for complete information contained in our new easy to use Phoenix Catalog, No. 61-7MD

PHOENIX ELECTRIC MANUFACTURING CO.
3625 N. HALSTED ST. • CHICAGO 13, ILL.

Circle 325 on Page 19

ALL Your Needs in Laminated Plastic Tubes



An Example of
Synthane *You-shaped* Versatility

At Synthane we have the versatility to give you just about everything you want in laminated plastic tubing or parts. Over 25 standard grades including those complying with governmental specifications. Sizes 3/32" ID up to 26¼" OD. Lengths 18" to 96". Wide range of wall thicknesses. Selection of colors and finishes. Molded and rolled tubing. Variety of cross sections—round, oval, square, polygonal, etc. Our excellent fabrication facilities provide you with finished parts to your specifications.

You-shaped Versatility makes Synthane a Better Buy in Laminates

SYNTHANE CORPORATION OAKS, PENNA.

Synthane Corporation, 5 River Rd., Oaks, Pa.
Gentlemen:
Please send me information about Synthane as a source for laminated plastic tubes and parts fabricated from tubes.

Name_____

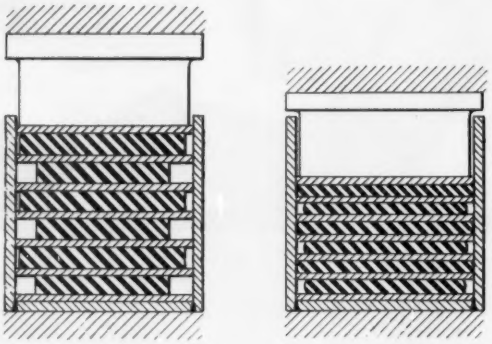
Address_____

City_____ Zone____ State_____

inlet passage. Inducer comprises a cylindrical member connected at the suction side of the impeller and provided with helical vanes formed along the wall of the bore. *Patent* 2,984,189 *assigned to Worthington Corp., Harrison, N. J., by Walter K. Jekat.*

Stacked-Disc Spring

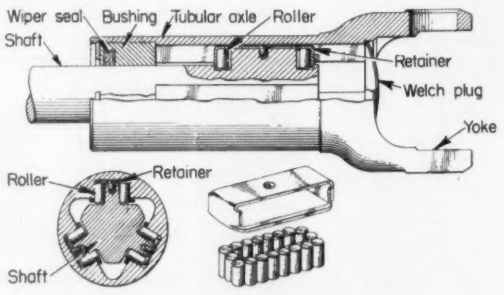
Discs of metal and rubber, alternately stacked within a housing, form a variable-gradient compression spring. Preferably, alternate rubber layers of increased diameter expand to the housing wall under applied load. The moment the housing wall is touched, spring



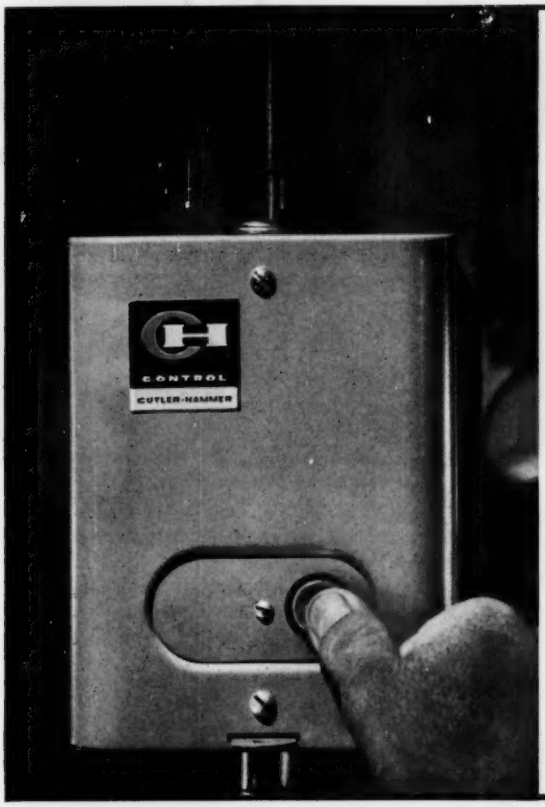
gradient is increased. Thus, under further increase in load, the rate of spring travel is decreased. In addition, high energy absorption is achieved by frictional movement between the rubber discs and intermediate metal layers. *Patent* 2,982,536 *assigned to Mobay Chemical Co., Pittsburgh, Pa., by Heinrich Kordes.*

Telescoping Slip Joint

A drive shaft, telescopically joined to a suspension axle by a splined roller joint, works freely under high-torque load. Three tapered lugs extending from the shaft are fitted into recesses provided in the axle. Surrounding each lug is a train of steel rollers. These



rollers are held and guided by a retainer fitted with deflector fingers to facilitate rotation around the lug. Tapered configuration of the shaft lugs minimizes loading of the rollers under clockwise or counterclockwise rotation. *Patent* 2,983,120 *assigned to General Motors Corp., Detroit, Mich., by Robert L. White.*



CONTROL

New! Cutler-Hammer Size 00 A-C Magnetic Starter... 20% smaller...18% less cost

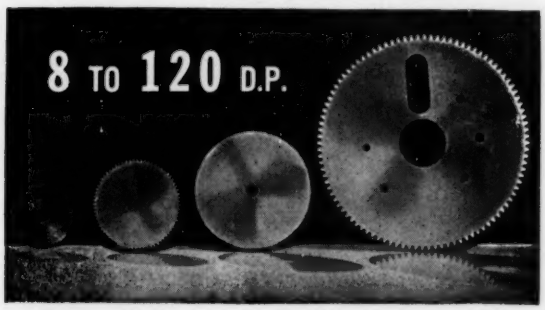
Now save space and money with the all new Cutler-Hammer Ac-Magnetic Starter. The new Size 00 fits about 40% of the applications where the Size 0 is now used. You still get the famous Three Star line quality—same high reliability—famous vertical, dust-free silver contacts. Max. hp ratings: 3 phase: 208/220V., 1½ h.p. 440/550V., 2 h.p. Single phase: 115V., ½ h.p. 230V., 1 h.p. Get it open or in NEMA 1 enclosure. Send for Pub. LO-40-N243.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer, Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer, Mexicana, S. A.

Circle 327 on Page 19



LONG LIST OF STOCK GEAR DIES OFFERS YOU BIG SAVINGS!

ACCURATE STAMPED GEARS by *WINZELER* are BIG savers of time and money. Single stampings are laminated to wide faces at savings up to 60%! Further economies are made possible by a BIG range of *stock* Dies. Modern new plant, methods, and equipment now greatly increase production speed, efficiency and *economy!* Send blue prints. Tell us about your needs today. No obligation.

SEND FOR...

New list of WINZELER-made stock Gear Dies. Ask for it on company letterhead, *please!*

WINZELER Stamped Gears

WINZELER MANUFACTURING & TOOL CO.
7355 W. WILSON AVENUE • CHICAGO 31, ILLINOIS

Circle 328 on Page 19

SAVE TIME
SAVE DOLLARS
SOLVE PROBLEMS

Write today for

STAR'S STAINLESS HINGE FACT SHEET

RIGHT OFF-THE-SHELF® ...

- More than 30 different sizes and types including continuous or piano type hinges, butt hinges in blank, fixed pin and loose-pin types, etc.
- Wide range of variations for special applications.

HELP YOURSELF from Star's new catalog of stainless steel hinges and other stainless steel fastenings.

Write, wire, phone for your copy RIGHT NOW

CORROSION RESISTANT

STAR STAINLESS SCREW CO.

458 Union Blvd., Paterson 2, New Jersey
Telephone: CLifford 6-2300
Direct New York phone: WIsconsin 7-6310
Direct Philadelphia phone: WAlnut 5-3660

Circle 329 on Page 19

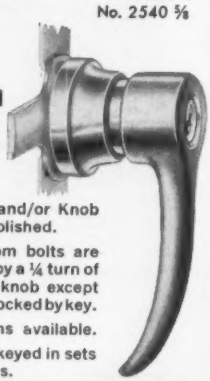
designs by

CORBIN

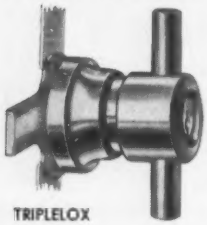
FOR A LIFETIME OF FAULTLESS PERFORMANCE

Smart looking, too

TRIPLELOX
No. 2540 ⅝



CHOICE OF 1, 2 or 3 POINT LOCKING WITH OR WITHOUT PIN TUMBLER LOCKING MECHANISM

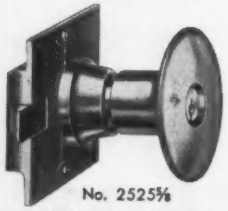


TRIPLELOX
No. 2510

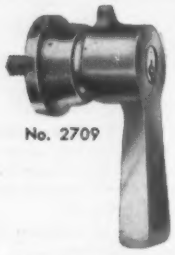
- Lever Handle and/or Knob cast bronze, polished.
- Top and bottom bolts are cam operated by a ¼ turn of the handle or knob except when they are locked by key.
- Variety of cams available.
- Can be masterkeyed in sets with other locks.

ONE POINT LOCKING WITH OR WITHOUT PIN TUMBLER LOCKING MECHANISM

- Knob and Rose cast bronze, polished.
- Latch bolt operated by a turn of knob except when locked by key.
- Can be masterkeyed in sets with other locks.



No. 2525⅝



No. 2709

CONTROL LOCK WITH INDICATOR. PIN TUMBLER LOCKING MECHANISM

- Handle can be furnished in from 1 to 6 positions to order.
- Handle and Rose are cast bronze, polished.
- Can be masterkeyed in sets with other locks.

These and many other items complete the extensive CCL Line. Design and Engineering Service available on request.

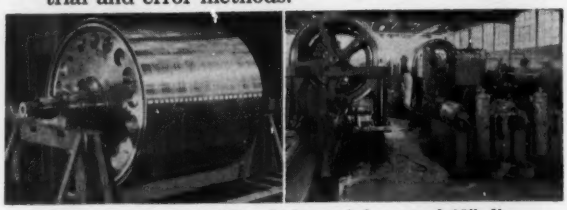
CORBIN

CORBIN CABINET LOCK DIVISION
THE AMERICAN HARDWARE CORPORATION
NEW BRITAIN, CONNECTICUT

Circle 330 on Page 19

Specialists in Deep Hole Drilling

— the kind your own shop shies away from and on which you can't afford the excessive costs, long tooling delays and scrap that goes with trial and error methods.

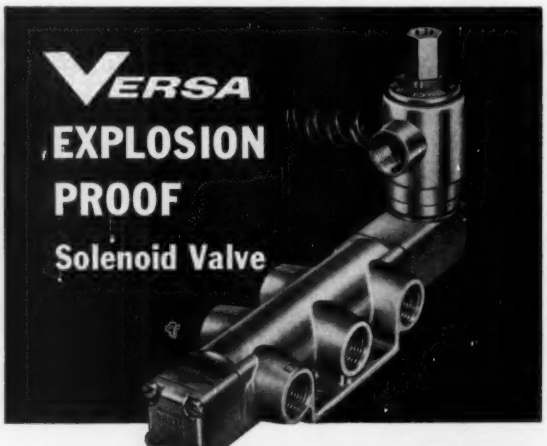


How tough can drilling be! 3 stainless steel 62" dia. forged rings, 22" long. 288 evenly spaced slots drilled and broached the length of the exterior wall of each ring as a separate project. When rings were assembled and bolted together, holes lined up perfectly.

We have 32 deep hole machines specially engineered to produce holes as small as .094" in depths up to 200 times diameter. Can hold close tolerances practically free of run-out. Also contouring and secondary operations. Drilled heat exchangers a specialty. Cleared for secret government work. WRITE FOR BROCHURE "HOLES".

20TH CENTURY MACHINE CO. / UTICA, MICH.
PHONE JE. 9-0660

Circle 331 on Page 19



■ Now . . . You can get Versa Valves with Explosion Proof Solenoid actuation. This new actuator is available on any series "V" and "T" Valves in sizes from ⅛" NPT to ½" NPT in 2-, 3-, 4- and 5-way types, in side port models or sub-plate models for manifold mounting, and for pressures from partial vacuum to 500 PSIG. ■ These superior valves are completely enclosed units, having no external moving parts and they are virtually trouble free. ■ All Versa Valves are triple pressure and functionally tested under water for guaranteed leakproofness. ■ For complete information write today for Bulletin #660.

VERSA Valves

VERSA PRODUCTS COMPANY, INC.
150M COOLIDGE AVE., ENGLEWOOD, NEW JERSEY

Circle 332 on Page 19

"Dyflon"®

Self-Aligning and Self-Lubricating SPHERICAL BEARINGS

Combine "Monoball"® Engineering Advantages with Life-Time Lubrication

Design engineers in many industries are specifying new "DYFLON"® SELF-ALIGNING and SELF-LUBRICATING SPHERICAL BEARINGS for these 5 major reasons:

1. **LOWER COEFFICIENT OF FRICTION** ...ideal where lubrication is impossible or undesirable.
2. **WITHSTAND EXTREME VIBRATION** ...perfect performance under shock load conditions.
3. **WILL NOT "COLD-FLOW"** ...even under extreme load conditions.
4. **IMPERVIOUS TO KNOWN CHEMICAL SOLVENTS** ...eliminates corrosion problems.
5. **FAIL-SAFE** ...due to "Monoball"® design.

Request Engineering manual No. 551.

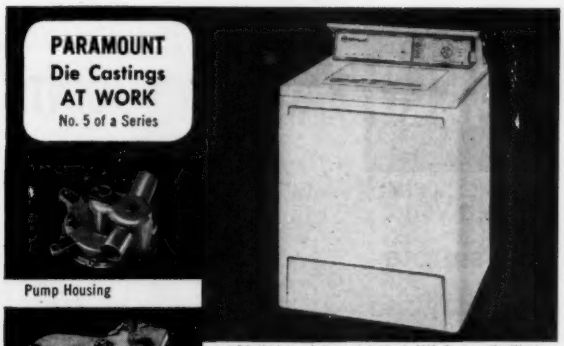
In addition, due to their two-piece "MONOBALL"® design and plastic alloy insert, "DYFLON"® bearings have a long cycle life. Alignment and installation problems are minimized. Oil-free for life means lowest possible maintenance costs.

Available in a variety of plain or rod end types. Bore sizes to 3.000". Materials include stainless steel, plastic alloys and chrome alloy steels. Ultimate static loads to 500,000 lbs.

SOUTHWEST PRODUCTS CO. 1705 SO. MOUNTAIN AVE. MONROVIA, CALIF. · PHONE: MURRAY 1-9616

Circle 333 on Page 19

PARAMOUNT Die Castings AT WORK
No. 5 of a Series



Pump Housing

Gear Case Cover

RCA-Whirlpool Imperial Mark XII Automatic Washer

PARAMOUNT—a major supplier of die castings to Whirlpool Corporation for 15 years

Whirlpool quality is recognized throughout the world, quality which stems from the rigid quality standards which Whirlpool demands that its suppliers meet.

Paramount's engineering and production "know-how", its ability to consistently meet Whirlpool's exacting quality standards—as in these die castings for the RCA-Whirlpool Imperial Mark XII Automatic Washer—are the reasons why Paramount has consistently been one of Whirlpool's major suppliers for 15 years.

It Will Pay You To Look to Paramount . . .

If your product incorporates die castings or you're considering them—investigate Paramount's complete services.

Three complete plants—two in St. Joseph, Mich., one in Seymour, Indiana.

SEND For "Designing for Die Casting"

PARAMOUNT *Die Casting Co.*

(A subsidiary of TALON, INC.) **ST. JOSEPH 3, MICHIGAN**

Circle 334 on Page 19

IDEAS! for heavy equipment designers

Looking for new solutions to heavy-duty power problems? This new brochure has full information on heavy-duty transmissions with input torque capacities of 150 to 2500 ft-lb. Included is "idea material" describing:

- Standard transmissions customized to each application
- Wide variety of "engineered-to-order" transmissions
- Specifications (capacities, speeds, gear ratios) for heavy-duty applications
- Examples of single-speed, multiple-speed and right angle drive transmissions

Send coupon for your free copy . . . or see our Catalog in *Sweet's Product Design File* today!

Cotta Transmission Co., 2340 - 11th Street, Rockford, Illinois
Please send my copy of "Cotta Heavy-Duty Transmissions" to

Name_____ Title_____

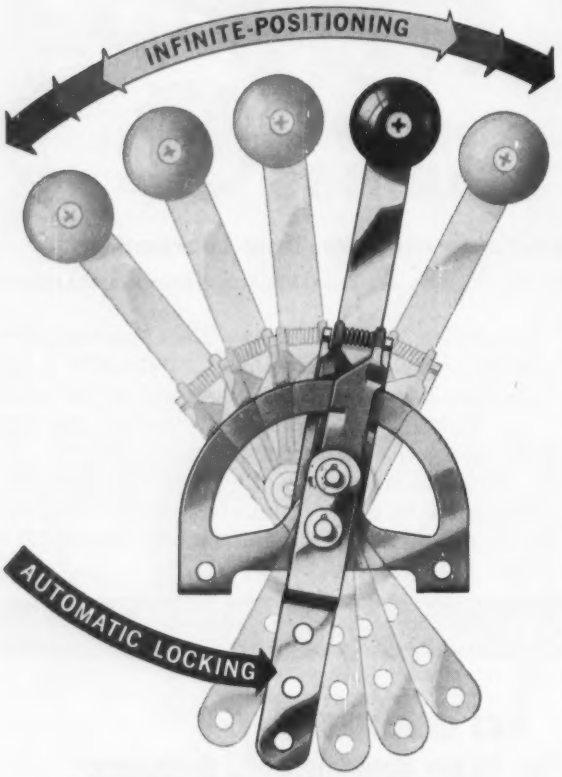
Company_____

Address_____

City_____ Zone_____ State_____

Circle 335 on Page 19

the ADAMS RITE QUADRASTAT CONTROL



APPLICATION:

...wherever positive control and automatic self-locking are required.

The Adams Rite QUADRASTAT Control employs a self-locking principle which permits infinite-positioning through use of the primary handle, but absolutely prevents any creepage or change of setting due to vibration or "feed-back" forces acting through the driven or actuating lever.

Uniquely engineered and comprised of only 5 main elements, the sturdy but lightweight QUADRASTAT is presently in trouble-free use on a wide range of control operations. It has been successfully incorporated into such diverse applications as tractor throttles, hydraulic valves, governors, air ducts, power boats, jet engines, and aircraft drag-brakes. The versatile unit may be manually, hydraulically, or motor controlled, and is available with handle, actuating lever, and quadrant mounted in various positions.

To learn how the QUADRASTAT can solve your control problem, write today for complete details and specifications, Department C-3.

"Over half a century"

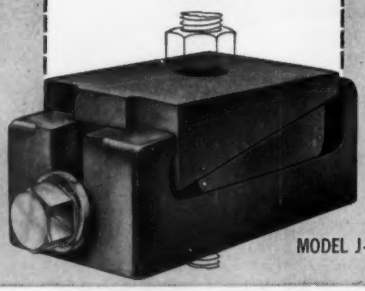
ADAMS RITE
MANUFACTURING COMPANY
540 West Chevy Chase Drive
Glendale 4, California

212

Circle 336 on Page 19

EMPCO

VERTICAL-MOTION LEVELING JACKS



AT LAST—A WEDGE-TYPE MACHINE LEVELING JACK THAT LIFTS... BUT DOESN'T SHIFT

A major advance in precise machine leveling, the new Empco Vertical-Motion Jack gives you the convenience, adjustability and precision of wedge-type leveling—*without lateral stress or shifting.* Just a simple turn of the hex screw lifts up to 20,000 pounds, easily and precisely—keeps machines performing at their level best! Jack automatically compensates for uneven floors up to five degrees and may be used with anchor bolts where desired.

EMPCO LEVELING JACKS

SEND TODAY FOR BULLETIN 200

Enterprise Machine-Parts Corp., 2723 Jerome Ave., Detroit 12, Mich

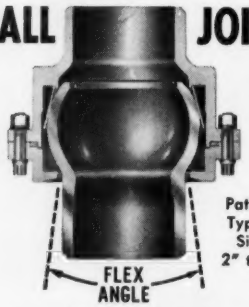
Circle 337 on Page 19

BARCO

High Temperature (from 500° to 1200°F)

BALL JOINTS

NEW! A simple way to solve



Patented Type HT Sizes: 2" to 16"

PIPE EXPANSION PROBLEMS

Send for New Catalog No. 250

BARCO

At risers . . . at offsets . . . in straight runs, install Barco Flexible Ball Joints to handle any amount of PIPE EXPANSION—also twisting, torsional movement. Here's why it PAYS:

Save Time—Expensive engineering and stress analysis not required.

Cut Costs—No "pressure end thrust" in Barco joints; heavy anchoring and pipe guides not needed for installation.

Safety—Joints are *self-aligning* for protection against costly "mis-alignment" damage. No thin wall sections; no lubrication needed.

Save Space—One foot of offset (between ball center points) provides for 3" expansion. *Find out about this method; send for literature.* BARCO MANUFACTURING CO., 506 H Hough St., Barrington, Illinois.

Circle 338 on Page 19

for millions of precision motions...

THE WORLD TURNS TO DYNACO

If you're looking for prototype precision in quantity production with immediate delivery schedules, you just can't beat DYNACO Precision Stock Gears and Assemblies engineered to answer every conceivable transmission requirement.

More than 50,000 different off-the-shelf gears and components are listed in Dynamic's Catalog F-128. Send for your copy today.

Dynaco GEARS

a product of

DYNAMIC GEAR COMPANY, Inc.

175 Dixon Avenue • Amityville, Long Island, N. Y.

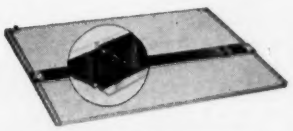
Telephone: AMityville 4-4788 • Teletype: Amityville, N. Y. 640-U

Western Division: 8912 Sepulveda Blvd., Van Nuys, California

P.O. Box 4156 • Telephone: EMpire 2-3125 • Teletype: SNFD-4436

Circle 339 on Page 19

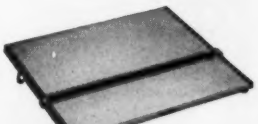
MAYLINE



PARALLEL RULING STRAIGHTEDGE

Choose Mayline Drafting Equipment

With Mayline drafting furniture and equipment you get quality workmanship and materials, high performance, durability, and pleasing appearance. All products discussed in Catalog 11. Write for your copy today.



PROFESSIONAL DRAWING KIT

MASTER DRAWING TABLE

MAYLINE CO., INC.

601 No. Commerce St.

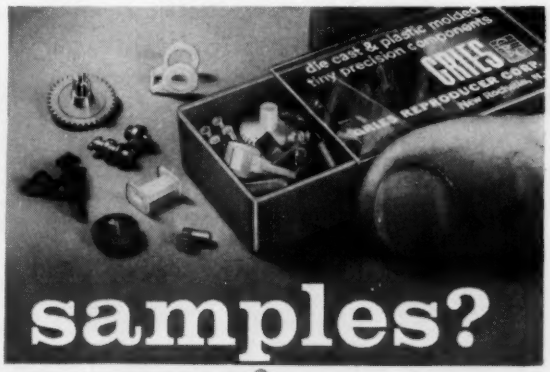
Sheboygan, Wisconsin

MAYLINE

MAYLINE

MAYLINE

Circle 340 on Page 19



samples?

sure!

SEE FOR YOURSELF HOW

GRC TINY PARTS

DIE CAST ZINC ALLOY and
MOLDED ENGINEERING THERMOPLASTICS

. . . **combine high quality, uniformity, accuracy** . . . at low cost.

GRC's exclusive high-speed, automated single cavity techniques give you higher quality, more uniformity, offer important production and assembly shortcuts with precision small parts in die cast zinc alloy and molded plastics.

These FREE SAMPLES and detailed bulletins on GRC's unique services will show you why you can **do** more . . . **save** more . . . when you **know** more about GRC. Write for yours TODAY—on company letterhead.

NO SIZE TOO SMALL!

MAXIMUM SIZES:
Zinc Alloy—2", ½ oz.
Nylon, Delrin & other engineering thermoplastics—1¼", .03 oz.

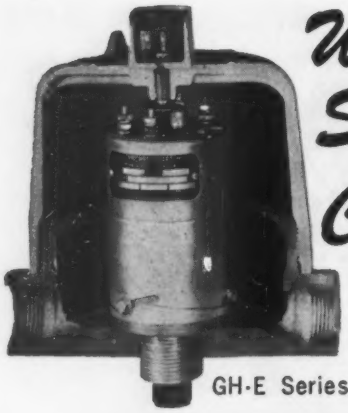
GRIES

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

32 Second St., New Rochelle, N. Y. • NEw Rochelle 3-8600

Circle 341 on Page 19



GH-E Series

Where Safety Counts

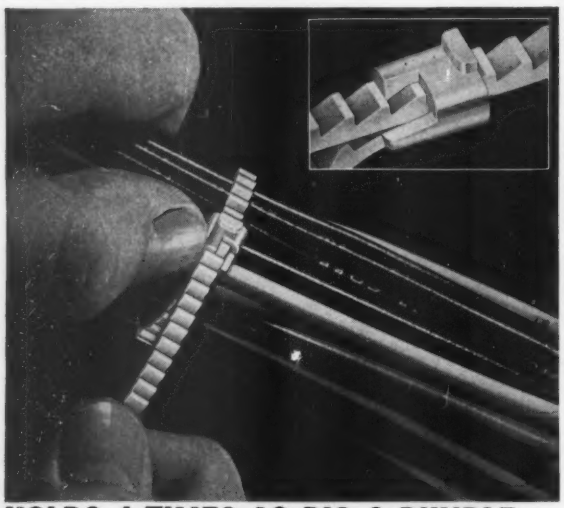
EXPLOSION PROOF

SPEED SENSITIVE SWITCHES

All GH series of cable driven governors and switches are available in this GH-E series. This housing meets the specifications for class 1 group D, Explosion Proof Equipment. For further information, write for Bulletin 504-A.

SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVE., SKOKIE, ILL.

Circle 342 on Page 19



HOLDS 4 TIMES AS BIG A BUNDLE— HOLDS AT 50 G'S

Genuine Bund-L-Tite* nylon straps are twice as long and fully 10 times as strong as any other bundle-tying strap made. This means that you can secure larger bundles at greater stresses. Bund-L-Tite is fast and simple, too: just pull the self-locking strap around the wires. No tying, no knots, no hitches to come loose. Light-weight DuPont zytel meets MIL-P-17091. ⅛" size holds 40 lbs. tension; 3/16", 175 lbs.; ¼", 325 lbs. IMITATED BUT NOT DUPLICATED. Write for free literature.

DAKOTA ENGINEERING, INC.
4315 Sepulveda Blvd., Culver City, California

Manufacturer of Cab-L-Tite clamps.

*Trade Mark

NOW AVAILABLE

MACHINE DESIGN

Data Sheets

The repeated requests for reprints of MACHINE DESIGN's Data Sheets has resulted in the collection of this useful information into handy, compact manuals. Each manual contains the complete set of Data Sheets appearing in MACHINE DESIGN during a single year. This excellent source of engineering information provides a constant reference for engineers seeking valuable short cuts to design problems. Each manual sells for only $2.00 per copy yet pays big dividends in time saved.

These worthwhile Data Sheet manuals are the only ones of their kind available. Order a set today for your department or personal library. Use the convenient form below for prompt service.

MACHINE DESIGN
Penton Bldg.,
Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order)

Please send me:

_____copies of the 1959 Data Sheets
_____copies of the 1958 Data Sheets
_____copies of the 1957 Data Sheets
_____copies of the 1956 Data Sheets

Total: _____copies @ $2.00 per copy $_____

NAME _____

COMPANY _____

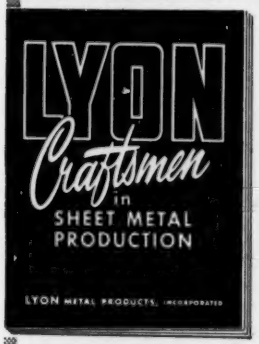
ADDRESS _____

CITY _____ ZONE _____ STATE _____

(Add 3% to orders in Ohio to cover State Sales Tax)

DO YOU NEED
a low-cost source of metal fabricating?

Three large, well equipped plants at **Aurora, Ill., York, Pa.** and **Los Angeles** geared to economical production. Experienced in handling thousands of special items . . . products, parts, sub-assemblies, merchandising units, made to your specifications.



Modern equipment includes coil steel slitting, leveling and edging, press work, all types of welding, electrostatic finishing. Sound design and engineering counsel.

Send for 16-Page Booklet
It tells All!

LYON METAL PRODUCTS, INC.
General Offices, 781 Monroe Avenue, Aurora, Illinois

Circle 344 on Page 19

air dries . . . resists corrosion

HEAT-REM H-120A
for 1200° temperatures

Heat-Rem H-120A is the ideal coating for temperatures up to 1200° F. It's easy to use . . . air dries without baking to an attractive hard aluminum coating in 6 hours . . . resists industrial fumes, most acids, salt spray and weathering.

Of extra heavy viscosity, H-120A is economical for either interior or exterior use. It is recommended for exhaust manifolds, mufflers, boilers, heat lines, pickling and boiling vats, etc.

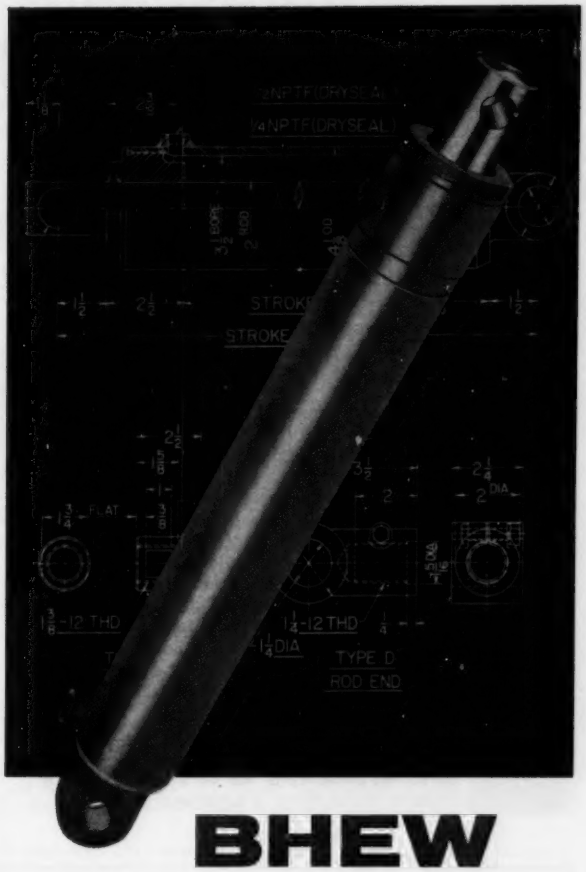
Heat-Rem H-120A meets or exceeds government and industrial specifications. Brush, spray or dip application.

A-4066A

$10.85 PER GALLON

SPECO, Inc.
"REM" PRODUCTS
Cleveland 9, Ohio

Circle 345 on Page 19



BHEW
Hydraulic Cylinders

- Basic Designs
- Specific Adaptations
- Superior Quality
- Application Engineering

BHEW SINGLE-ACTING GENERAL-PURPOSE CYLINDERS (1500 PSI PISTON STYLE SERIES) are designed around standard components but custom-built to suit *your* application. They're available in a variety of mountings (pin eye is standard) with adjustable or non-adjustable rod ends, with or without rod ends.

• Self-adjusting "U" cup seal on pistons • Self-adjusting rod wipers • Honed steel barrel, high-tensile, hard chrome-plated rod ends • Packings available for extreme high and low temperatures and most non-inflammable fluids. •

Production parts save you money, do the job better! BHEW basic cylinders can easily be modified to fit your *specific* product applications. You benefit from production economies; you get custom-built cylinders.

Let's discuss your design and application problems —

FREE!

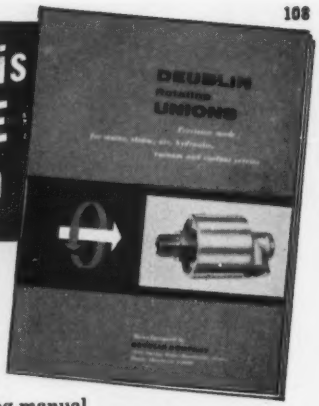
Write today for Hydraulic Cylinder Engineering Reference data — 78 dimensional basic designs for general-purpose and special-purpose double-acting and single-acting cylinders. SAVE TIME.

BENTON HARBOR ENGINEERING WORKS, INC.
622 Langley Avenue St. Joseph, Michigan

Circle 346 on Page 19

108

Send For This NEW FREE Catalog On



DEUBLIN Rotating UNIONS

A completely new, 20 page illustrated catalog-manual showing all the models of Deublin Rotating Unions for water, steam, air, hydraulic, vacuum and coolant service for the machines you make or use, is just off the press to help you get trouble-free service and reduce your "down-time" and keep maintenance to a minimum. Shown are rotating joints for water and steam service; monoflow and duoflow unions; single and double passage rotating air unions; hi-pressure lo-torque unions; extra capacity air unions; rotating siphon pipe unions; in-the-shaft mounted unions; hydraulic rotating unions and hi-speed coolant unions. Complete with full engineering data, cut-away drawings, plus instructions for installing, lubricating and servicing Deublin unions.

Write for your free copy today.

DEUBLIN COMPANY

1923 STANLEY ST. • NORTHBROOK, ILL.

Circle 347 on Page 19

Why **HUSCO HYDRAULIC MULTI-PLUNGER VALVES**

HUSCO 3900-SP Valve

HUSCO 3300-SP, showing size range.

Fit a greater range of control needs

- Choice of FIVE Basic Model Sizes — over 120 standard valves for unlimited modifications to specific needs.
- Control up to SIX Cylinders, single or double acting.
- Up to FOUR Standard Control Positions — raise, lower, float and neutral.
- Available with Flange or Standard Mounting (3900 Valves only).
- Accurately Rated Capacities from 3 to 185 G.P.M. at 22 f.p.s. velocity.

These are only a few reasons why HUSCO Valves are more flexible in adaptation to your needs, more efficient in power-saving control.

Write for HUSCO Catalog "Hydraulic's House of Ideas" — and for expert engineering assistance on your hydraulic control.

HUSCO

HYDRAULIC UNIT SPECIALTIES CO.

PUMPS • VALVES • CYLINDERS
P. O. Box 257-M, Waukesha, Wisconsin
West Coast Representatives
EASTMAN PACIFIC CO., Los Angeles, Calif.
ROY BOBBS AIR-DRAULIC CO., Portland, Ore.

Circle 348 on Page 19

MACHINE **DESIGN** OFFERS TWO TECHNICAL REPRINTS

An Engineering Approach To HYDRAULIC LINES

A design engineer's handbook covering the selection and application of hydraulic conductors.

- Fundamentals of Line Flow
- Determining Line Size
- Selecting Hydraulic Tubing
- Selecting Hydraulic Pipe
- Selecting Hydraulic Hose
- Selecting Hydraulic Connections

$1.00 a copy

PATENT FUNDAMENTALS

A basic guide to what the company and engineer should know about handling ideas, inventions and patents. Sixteen pages explaining, in layman's language—

- Patentable Inventions
- Company Approach
- The Patent Application
- Patent Interference
- Licenses
- File-Wrapper Estoppel
- Outside Inventors
- Design Patents
- Copyrights
- Trademarks
- Service Marks

Single copies FREE, $1.00 for 10

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Please send me____copies of "Hydraulic Lines."
Please send me____copies of "Patent Fundamentals."

Remittance or Company Purchase Order must be enclosed with order.

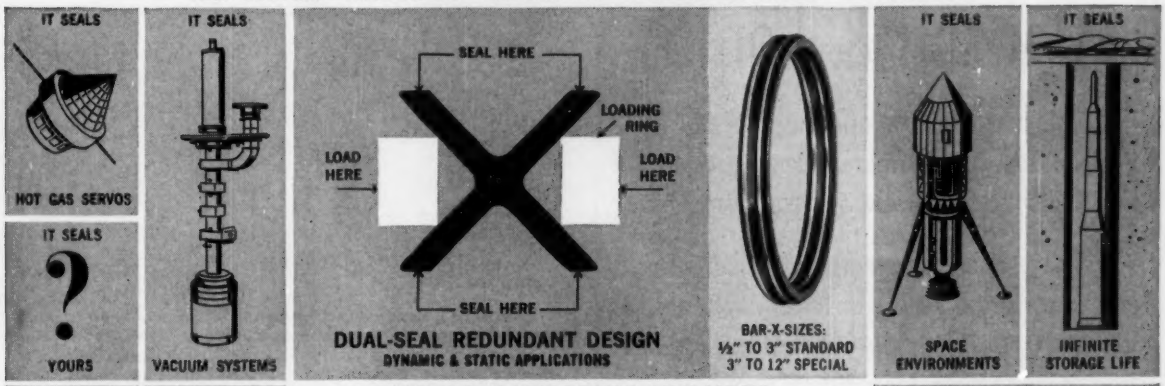
NAME _____
COMPANY _____
ADDRESS _____
CITY _____ ZONE ____ STATE _____

(Add 3% to orders for delivery in Ohio to cover State Sales Tax)

BAR-X® SEALS EVERYTHING

AT TEMPERATURES FROM −400° F TO +1500° F!

ANY FLUID—GAS—FUELS—WATER—LIQUID METALS—CRYOGENIC FLUIDS—CORROSIVE FLUIDS
ANY SYSTEM—HYDRAULIC—PNEUMATIC—VACUUM—CRYOGENIC—NUCLEAR



NO CATASTROPHIC FAILURES
INFINITE STORAGE LIFE
UNPRECEDENTED SERVICE LIFE

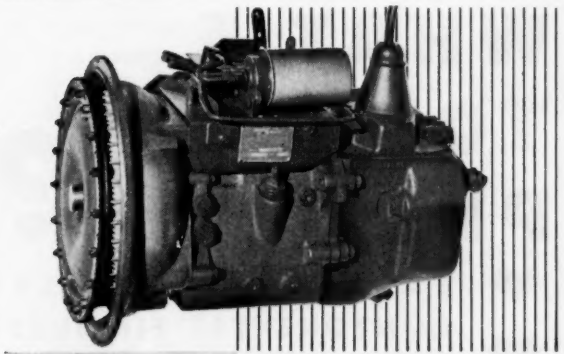
Eliminates critical downtime ■ Very high and very low pressure ■ Easy, foolproof installation (not a mechanism) ■ All-metal—non-contaminating ■ Stable, symmetrical design

WRITE TODAY FOR THE FULL STORY! SALES ENGINEERS IN PRINCIPAL CITIES.

Wiggins

E. B. WIGGINS OIL TOOL CO., INC., Dept. F1
3424 E. Olympic Blvd., Los Angeles 23, Calif.
TWX 1403U, Phone AN 9-0181

Circle 349 on Page 19



FUNK UNITS ASSURE SMOOTH POWER SHIFTING

On this Getman Scoot-Crete ore carrier, a FUNK Revers-O-Matic® Drive installation delivers smooth, instant power shifting — forward and reverse — with just one foot pedal. And a FUNK TORQUE CONVERTER automatically adjusts power to speed and load requirements, eliminates wheel spinning.

Just one example of how FUNK MODULAR POWER UNITS may be combined — in an unlimited number of arrangements — *without* special engineering costs.

Let FUNK help solve your power transmission problem.

FUNK MFG. CO. Box 577-F Coffeyville, Kan.

Circle 350 on Page 19

New GEMCO ROTATING CAM LIMIT SWITCH

PRECISION CAM ADJUSTMENT *WITH A SCREW DRIVER...*

IN SECONDS!

One type cam . . . no special cam lobes required.

Snap Action Switches, N. O. and N. C.—electrically separated

2 through 12 circuits. Available in NEMA 1, 4, 5, 7, 9 and 12 enclosures.

Please send Bulletin 558 for complete story of new Gemco Rotating Cam Limit Switches.

NAME_____

COMPANY_____

CITY_____ ZONE____ STATE_____

GEMCO ELECTRIC COMPANY
25685 West Eight Mile, Detroit 40, Mich.

Circle 351 on Page 19

ENGINEERS

Bausch & Lomb

There are several openings for Senior Design Engineers in the Product Design Sections of our company.

These are permanent positions requiring the ability to take Mechanical Design responsibility from concept to a saleable product. Products involved are mechanical-electrical-optical in nature. Mechanical Engineering Degree and at least 5 years of mechanical experience is required. Optical or electrical background helpful but not necessary.

Positions require board design, coordination of customer requirements with Electrical and Optical Engineers, supervision of detail draftsmen, assistance to shop during construction and assembly as well as testing and development work.

Those who can qualify and are interested in real design responsibility are invited to send resume with salary requirements to E. P. Faro, Professional Employment.

Bausch & Lomb
INCORPORATED
13 Bausch Street
Rochester 2, New York

ENGINEERS
AVAILABLE OR WANTED

AVAILABLE: Experienced mechanical engineer, wide background in gears and related transmission elements for turbomachinery; looking for responsible assignment using this background in design, development, teaching, manufacturing, or consulting. Reply to Box 994, MACHINE DESIGN, 1213 West Third Street, Cleveland 13, Ohio.

WHAT S YOUR PROBLEM ?

PARTS? MATERIALS? COMPONENTS? FINISHES?

Perhaps one of our advertisers in this issue of MACHINE DESIGN has the solution to your dilemma. We'll be willing to bet that this issue contains information that is essential to answering your problem.

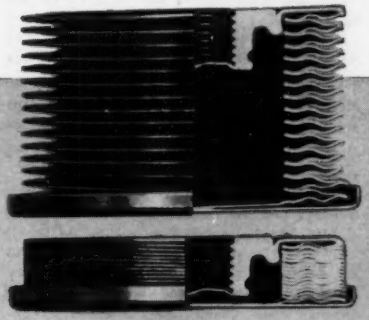
Fill out one of the yellow inquiry cards and send it to us. No letter or postage is necessary. We will forward your inquiry to the advertiser and he will reply directly to you.

Why not do it right now?

USE THE YELLOW CARD ON PAGE 19.

WELDED DIAPHRAGM BELLOWS By METAL BELLOWS CORP.

111-1C



Lear · H HONEYWELL · MORDEN

SANDERS ASSOCIATES, INC.
NASHUA, NEW HAMPSHIRE

NORTRONICS
A Division of
NORTHROP CORPORATION

Used by Leading Manufacturers of Guidance and Propulsion Systems In Aero-Space Applications

Where extreme accuracy, reliability and consistent performance are specifications . . . you can depend on the pioneers and leaders in welded metal diaphragm bellows research, engineering and manufacturing to deliver the results.

Design and manufacturing services are available in full depth from our plants on the east and west coasts.

METAL Bellows CORPORATION

106 MICA LANE, WELLESLEY HILLS 82, MASSACHUSETTS • Pacific Division: 20972 Knapp Street, Chatsworth,(L.A.) California

Circle 353 on Page 19

BASIC ENGINEERING HELP FROM

MACHINE DESIGN

FOR VEHICLE DESIGNERS ONLY

MOBILITY OF CROSS-COUNTRY VEHICLES

A series of articles presenting up-to-date design data and mathematical methods for analyzing off-the-road locomotion of vehicles.

Matching vehicle design to
- soil characteristics
- thrust
- flotation
- motion resistance
- track and wheel requirements
- optimum loads

are the relationships covered in the booklet.

$1.00 a copy

FRICTION-CLUTCH TRANSMISSIONS

A basic guide for the selection and application of friction clutches to reliably join power transmission elements. Parameters for the balance of complete transmission systems, in the design stage, are presented in this four-part series.

$1.00 a copy

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Please send me_____copies of "Mobility of Cross-Country Vehicles"
Please send me _____copies of "Friction-Clutch Transmissions"

Remittance or Company Purchase Order must be enclosed with order.

NAME _____
COMPANY _____
ADDRESS _____
CITY _____ ZONE____ STATE_____

(Add 3% to orders for delivery in Ohio to cover State Sales Tax)

TIPS AND TECHNIQUES

VOLUME II ENGINEERING AIDS

- **Simplifying Constructions**
- **Utilizing the Slide Rule**
- **Construction Aids**
- **Shortcuts for the Engineer**

Helpful Tips and Techniques that apply to engineering methods, are now available in this one-volume reference. This manual contains 32 pages of illustrated time-and-money saving procedures that every engineer can use.

$1.00 a copy

Order from

MACHINE DESIGN
Reader Service
Penton Building
Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order)

Advertising Index

Acme Chain Corporation 191
Adams Rite Manufacturing Co. 212
Aero Hydraulics Division, Vickers, Inc., Division of Sperry Rand Corporation 65
Airborne Accessories Corporation 94
Allen-Bradley Co., The 50
Allied Chemical Corporation, Plastics Division 102
Allis, Louis, Co., The 48, 49
Alloy Products Corporation 178
American Hardware Corporation, The, Corbin Cabinet Lock Division 210
American Insulator Corporation 197
American Machine & Foundry Co., Potter & Brumfield Division 103
American Machine & Metals, Inc., The Lamb Electric Co. Division 97
American Metal Climax, Inc., Climax Molybdenum Co. Division 34
Ampco Metal, Inc. 187
Amplex Division, Chrysler Corporation 207
Anaconda American Brass Co. 27
Arwood Corporation 100
Automatic Switch Co. .....Inside Front Cover
Auto-Ponents, Inc. 207

Barber-Colman Co. 170, 171
Barco Manufacturing Co. 212
Bausch & Lomb, Inc. 218
Bellows-Valvair, Division of International Basic Economy Corporation 89
Bendix-Westinghouse Automotive Air Brake Co. 61
Benton Harbor Engineering Works, Inc. 215
Bower Roller Bearing Division, Federal-Mogul-Bower Bearings, Inc. 165
Bridgeport Brass Co., Cored Forgings Division 182
Briggs & Stratton Corporation 16
Browning Manufacturing Co. 46

Calumet & Hecla, Inc., Flexonics Division .. 77
Cambridge Wire Cloth Co., The 64
Carr Fastener Co., Division of United-Carr Fastener Corporation 87
Chain Belt Co. 9
Chemical Materials Dept., General Electric Co. 107
Chrysler Corporation, Amplex Division 207
Clearprint Paper Co. 63
Climax Molybdenum Co., A Division of American Metal Climax, Inc. 34
Columbia-Geneva Steel Division, United States Steel Corporation 51
Con-Vel Division, Dana Corporation 29
Corbin Cabinet Lock Division, The American Hardware Corporation 210
Cotta Transmission Co. 211
Crown Gear, A Division of Harrington & Richardson, Inc. 186
Cutler-Hammer, Inc. 209

Dakota Engineering, Inc. 214
Dana Corporation, Con-Vel Division 29
Doublin Co. 216
Dow Corning Corporation 105
Drop Forging Association 74
DuPont de Nemours, E. I., & Co., Inc. 11, 59, 60
Dynamic Gear Co., Inc. 213
Dynapar Corporation 47

Eastman Chemical Products, Inc. 205
Eaton Manufacturing Co., Farval Division .. 73
Electro Devices, Inc., Servospeed Division .. 182
Enterprise Machine-Parts Corporation 212
Erie Pacific Division, Erie Resistor Corporation 176
Erie Resistor Corporation, Erie Pacific Division 176

Fairchild Engine and Airplane Corporation, Stratos Division 194
Farval Division, Eaton Manufacturing Co. ... 73
Federal-Mogul-Bower Bearings, Inc., Bower Roller Bearings Division 165
Fellows Gear Shaper Co., The 101
Flexonics, Division of Calumet & Hecla, Inc. .. 77
Funk Mfg. Co. 217

Garlock, Inc. 72
Gates Rubber Co., The 33
Gemco Electric Co. 217
General Electric Co., Chemical Materials Dept. 107
General Electric Co., Industrial Sales Operation 52, 53
General Industries Co., The 176
Gleason Works 175
Gray Tool Co., Grayloc Sales Division 54
Gries Reproducer Corporation 213
Grip-Nut Co. 206

Hannifin Co. Division, Parker Hannifin Corporation 109
Harrington & Richardson, Inc., Crown Gear Division 186
Hart Manufacturing Co., The 194
Haynes Stellite Co., Division of Union Carbide Corporation 5
Heinemann Electric Co. 189
Hitachi, Ltd. 181
Howe Sound Co., Quaker State Metals Co. Division 55
Hydraulic Unit Specialties Co. 216
Hydreco Division, New York Air Brake Co., The 78

International Basic Economy Corporation, Bellows-Valvair Division 89
International Nickel Co., Inc., The 83

Jeffrey Manufacturing Co., The 98
Johns-Manville 88

Kaiser Aluminum & Chemical Corporation 68, 69, 70, 71
Kaydon Engineering Corporation, The 21
Keystone Steel & Wire Co. .....191 A

Lamb Electric Co., The, Division of American Machine and Metals, Inc. 97
LaSalle Steel Co. 7

Lau Blower Co., The 183
Lewellen Manufacturing Co. 15
Ling Electronics Division, Ling-Temco Electronics, Inc. 168, 169
Ling-Temco Electronics, Inc., Ling Electronics Division 168, 169
Link-Belt Co. 80, 81
Lockheed/Missiles and Space Division 104
Lucas-Rotax, Limited 66
Lyon Metal Products, Inc. 215

McGill Manufacturing Co., Inc., Bearing Division 92

Malayan Tin Bureau, The 172
Mayline Co., Inc. 213
M-D Blowers, Inc. 185
Mead Specialties Co. 1
Metal Bellows Corporation 219
Metals & Controls, Inc., Corporate Division of Texas Instruments, Inc. 173
Midland-Ross Corporation, Waldron-Hartig Division 198
Mina Bearing, A Division of MPB, Inc. 43
Minnesota Rubber 2
Moore, Samuel, & Co. 204
MPB, Inc., Mina Bearing Division 43
Mueller Brass Co. 44, 45

National Tube Division, United States Steel Corporation 51
New Jersey Zinc Co., The 110
New York Air Brake Co., The, Hydreco Division 78
Norgren, C. A., Co. 91

Ohmite Manufacturing Co. 93
Ortman-Miller Machine Co. 186

Packing Division, Raybestos-Manhattan, Inc. 56
Paramount Die Casting Co. 211
Parker Hannifin Corporation, Hannifin Co. Division 109
Pheoll Manufacturing Co., Inc. Inside Back Cover
Philadelphia Gear Corporation 86
Phoenix Electric Manufacturing Co. 207
Potter & Brumfield, Division of American Machine & Foundry Co. 103
Precision Castparts Corporation 201

Quaker State Metals Co., A Division of Howe Sound Co. 55

Raybestos-Manhattan, Inc., Packing Division 56
Republic Steel Corporation 84, 85
Robbins & Myers, Inc. 95
Rodney Metals, Inc. 192
Rogers Industries, Inc., Extrusion Division .. 67
Rohm & Haas 108

Servospeed, Division of Electro Devices, Inc. 182
Sigma Instruments, Inc. 179
Southwest Products Co. 211
Speco, Inc. 215
Sperry Rand Corporation, Vickers, Inc. Division, Aero Hydraulics Division 65
Square D Co. 57
Stackpole Carbon Co., Electronic Components Division 199
Standard Pressed Steel Co., Industrial Fastener Division 62
Star Stainless Screw Co. 209
Stearns Electric Corporation 190
Stratos, A Division of Fairchild Engine and Airplane Corporation 194
Superior Tube Co. 58
Synchro-Start Products, Inc. 214

Technology Instrument Corporation 192
Texas Instruments, Inc., Metals & Controls, Inc., Corporate Division 173
Thomson Industries, Inc. 177
Timken Roller Bearing Co., The .....Back Cover
Tinnerman Products, Inc. 99
Torrington Co., The 13
Torrington Manufacturing Co., The, Air Moving Divisions 75
Townsend Co., Engineered Fasteners Division 195
Twentieth Century Machine Co. 210

Union Carbide Corporation, Haynes Stellite Co. Division 5
Union Carbide Corporation, Union Carbide Plastics Co. Division 79
Union Carbide Plastics Co., Division of Union Carbide Corporation 79
United-Carr Fastener Corporation, Carr Fastener Co. Division 87
United States Steel Corporation, Subsidiaries 51
United States Steel Export Co. 51
United States Steel Supply Division, United States Steel Corporation 51

Veeder-Root, Inc., Electronic Controls Division 76
Versa Products Co., Inc. 210
Vickers, Inc., Division of Sperry Rand Corporation, Aero Hydraulics Division 65

Waldes Kohinoor, Inc. 106
Waldron-Hartig, Division of Midland-Ross Corporation 198
Warner Electric Brake & Clutch Co. 82
Waterman Hydraulics Corporation 172
Westinghouse Air Brake Co., Industrial Products Division 96
Westinghouse Electric Corporation, General Purpose Control Dept. 203
Westinghouse Electric Corporation, Standard Control Division 37, 38, 39, 40, 41, 42
White, S. S., Industrial Division 184
Wiggin, E. B., Oil Tool Co., Inc. 217
Williams-Bowman Rubber Co., The 188
Winsmith, Inc. 90
Winzeler Manufacturing & Tool Co. 209

Engineers Available or Wanted 218

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Publisher

RICHARD A. TEMPLETON
Director, Research & Promotion

MARY L. CALLAHAN
Advertising Service Manager

BARBARA O'LEARY
Reader Service Manager

AMY LOMBARDO
Circulation Manager

ROBERT E. LESSING
Production Manager

District Offices

New York 17 .....60 East 42nd St.
RUSSELL H. SMITH, JAMES A. STANGARONE
Murray Hill 2-2581

Simsbury, Conn. .....17 Deerfield Lane
ALAN C. BUGBEE, Oldfield 8-4764

Rochester 18, N. Y. .....175 Greenvale Drive
GEORGE M. ISBELL, Hillside 5-1771

Dresher (Philadelphia), Pa. ....1335 Harris Rd.
CHANDLER C. HENLEY, Mitchell 6-2585

Cleveland 13 .....Penton Bldg.
JACK W. WALTON, DON J. BILLINGS
Main 1-8260

Detroit 35 .....15800 West McNichols Rd.
H. F. SMURTHWAITE, Broadway 3-8150

Chicago 11 .....520 North Michigan Ave.
HOWARD H. DREYER, ROBERT Z. CHEW
DONALD A. IVINS, CHARLES F. REINER
Whitehall 4-1234

Los Angeles 36 .....5943 West Colgate Ave.
F. J. FULLER, Webster 1-6865

Los Angeles 5 .....730 South Western Ave.
The Robert W. Walker Co., Dunkirk 7-4388

San Francisco 4 .....57 Post St.
Robert W. Walker Co., Sutter 1-5568

Birmingham 9 .....249 La Prado Place
FRED J. ALLEN, Tremont 1-8598

Clearwater, Fla. .....1954 Jeffords Dr.
H. G. ROWLAND, Dial 441-4121

Dallas 35 .....525 Exchange Bank Bldg.
JAMES H. CASH, Fleetwood 1-4523

London, S.W. 1 ....2 Caxton St., Westminster

Published by
THE PENTON PUBLISHING COMPANY

GEORGE O. HAYS .....Chairman
RUSSELL C. JAENKE .....President
FRANK G. STEINEBACH ..Vice Pres. & Secretary
FRANK O. RICE .....Vice President
JOSEPH P. LIPKA ....Vice Pres. & Treasurer
DAVID C. KIEFER .....Vice Pres.—Marketing
IRWIN H. SUCH .....Vice Pres.—Editorial
ROBERT L. HARTFORD .....Vice President

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NBP

backtalk——

—Pushbutton Potables

Best friend of the busy bartender or the harried host could be a little machine called Cocktailmatic. Resembling a milkshake mixer when it isn't loaded, this device mixes ingredients for one, two, or three fresh martinis or manhattans when an appropriate button is pushed. It even offers dry, very dry, or very, very dry martinis.

Now for the part that will interest you engineers: A number of problems in materials selection faced Cocktailmatic's designers. They learned that the iron in stainless steel parts subject to constant rubbing contact will mix with the tannic acid in whiskey, turning it an inky black. So, a high nickel alloy was specified. Much time was spent finding plastic for the measuring cups and rubber for seals which wouldn't impart a foreign taste to alcohol. In making tests, the designers tried to use water but had to resort to real liquor because the surface tension of the two are different, and water won't pour in the machine.

AutoBar Systems Div. of American Machine and Metals Inc., which makes Cocktailmatic, points out that this isn't an example of automation, because it doesn't replace a person. Unfortunately, the button-pusher does not come with the machine.

—Facts on Fatigue

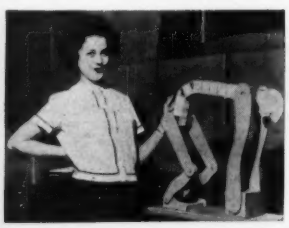
Your attention is called to a forthcoming publication on fatigue—not advice on how to get rid of that tired feeling, but practical information on factors which cause fatigue failures, how to anticipate them and eliminate them at the design stage. We refer to the series "Preventing Fatigue Failures," the last part of which appears in this issue, and all of which will be in a reprint (if the type holds up) available for $1.00 from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

—A Traumatic Transaction

Before any readers, or Messrs. Dow and Jones, mention it to us, we want to go on record with an acknowledgment of our misuse of stock-market parlance in the last issue. We started off Page 22 with an announcement that the employment market for engineers was "bullish," then proceeded to discuss a decline in demand. Too late, we discovered the slip of the thought process. But we do know the difference—and that's no bear.

—Help in Hefting

A silent instructor who doesn't mind being called a dummy is teaching employees at Dayco Corp., Melrose Park, Ill., how to avoid back injuries when lifting. The device works on a simple leverage principle. It has movable joints at the ankles, knees, hips, and shoulders; the spine is a series of wooden blocks held together by elastic strips. A student lifter operates the dummy by means of a handle at the base of its spine. If the load has been placed correctly—and the dummy's knees are bent and its back straight—it lifts properly, without harm to its back (left). However, if the load is too far forward, the dummy's wooden backbones separate. Any employee who has established empathy with the dummy will immediately realize the injury a human being would suffer under the same circumstances. Getting the message, Toni Galoti expresses alarmed concern for having made the dummy lift incorrectly. The gentleman who did it right is Ray Hart, safety director for Dayco.



and here's how Pheoll solved it

It's no picnic . . . this rising cost of labor and material . . . especially to a cost-control engineer.

However, new ways are constantly being found to improve quality while cutting expenses. In this instance a cost-conscious engineer, working closely with a Pheoll Sales Engineer, discovered how he could save his company money on a brass terminal item.

The fastener in the picture formerly had a hole drilled laterally through the head, into which a wire was inserted and soldered. It was necessary also to prevent the terminal from turning as the nut was tightened.

Pheoll facilitated the assembly operation by producing a brass terminal with special lugs under the head to prevent turning . . . and also incorporated a wide slot, instead of a hole, in the head to speed and simplify the wire connection when soldering.

Result was the reduction in cost of producing this fastener by 66%. One more example of the cost-conscious quality engineering . . . custom work you can expect . . . when you bring your fastener problems to Pheoll.

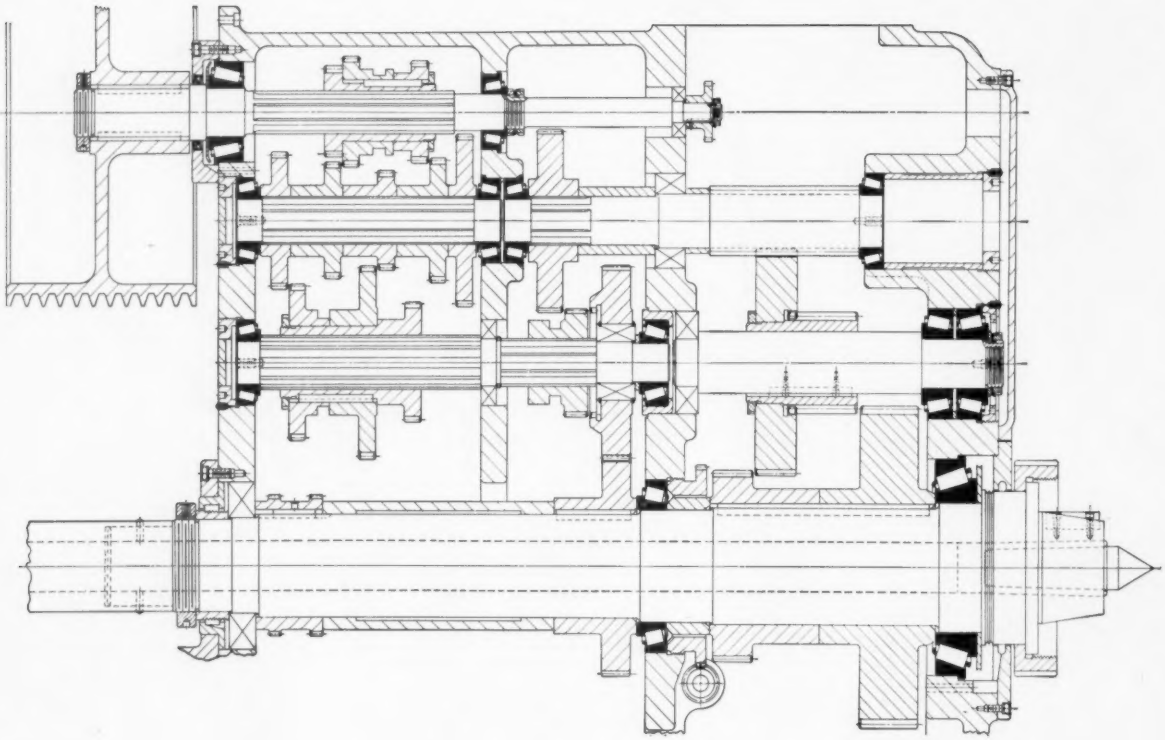
Pheoll Manufacturing Company, Inc.

5700 WEST ROOSEVELT ROAD CHICAGO 50, ILLINOIS

HEADING THE FASTENER INDUSTRY FOR OVER 50 YEARS

Circle 202 on Page 19

How world's largest tracer lathe assures precision



Engineers of The American Tool Works Co. design maintenance of high precision right into their new Maxi-Swing Tracer Lathe with 16 Timken® tapered roller bearings on the nose and center of the spindle, drive and intermediate shafts. That's because Timken bearings are designed and manufactured to take the big loads from all directions of this machine cutting ¾" deep into work pieces of up to 40 tons. And they do it through a range of 22 speeds, giving rigidity with compact mounting and ease of assembly.

ON-THE-SPOT ENGINEERING SERVICE. Our sales engineers can help you right at the design stage to get the most economical bearing in terms of needed capacity and precision. Why not call them in early?

Industry rolls on

TIMKEN®

tapered roller bearings

The Timken Roller Bearing Company, Canton 6, Ohio. Cableaddress: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ontario.

Circle 203 on Page 19